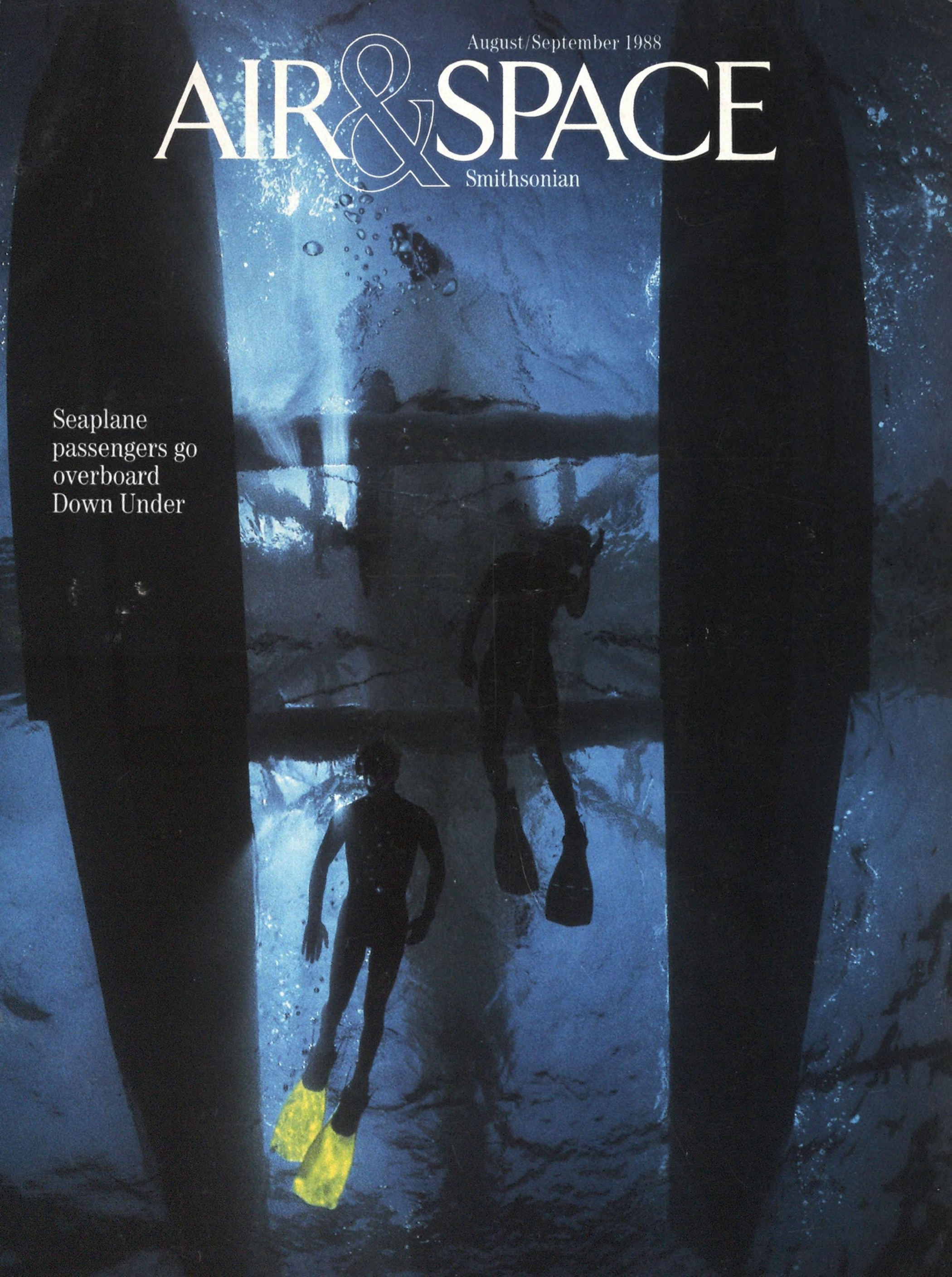
August/September 1988

AIR & SPACE

Smithsonian

Seaplane passengers go overboard Down Under



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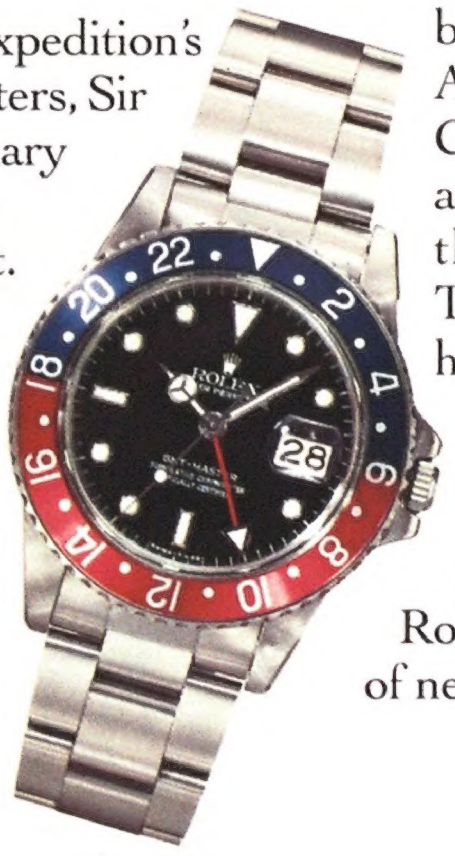
1926: The world's first truly water-and-shockproof watch is created when Rolex sculpts the revolutionary Oyster case from a solid block of metal.

1927: Mercedes Gleitze swims the English Channel wearing her Rolex Oyster. Both swimmer and watch emerge in France functioning flawlessly.

1935: Auto racer Sir Malcolm Campbell and his Rolex Perpetual speed to a new world record of 300 miles an hour.

1953: Synchronizing the expedition's teamwork on Rolex Chronometers, Sir Edmund Hillary climbs to the summit of Mt. Everest, the world's highest peak.

1960: Dr. Jacques Piccard breaks the world record with a 35,000-foot deep-sea dive. The Rolex Oyster strapped to his bathyscaphe never misses a minute.



1973: Neither searing heat nor violent sandstorms can stop Tom Sheppard and his Rolex Oyster on their historic Sahara crossing.

1975: Six Comex divers, coordinating their descent on Rolex Sea Dweller watches, reach a record depth of 1,070 feet.

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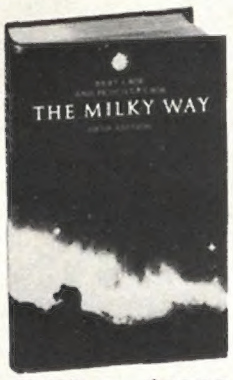

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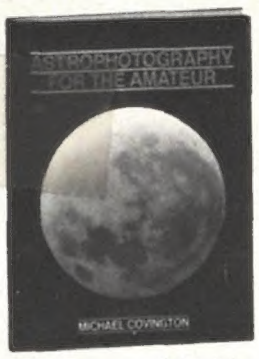

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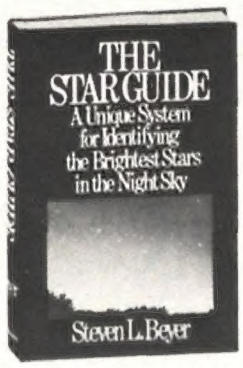

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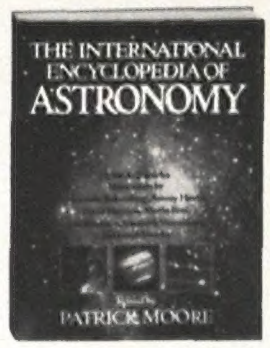

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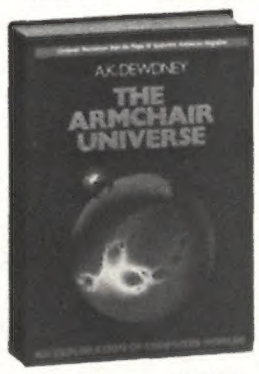

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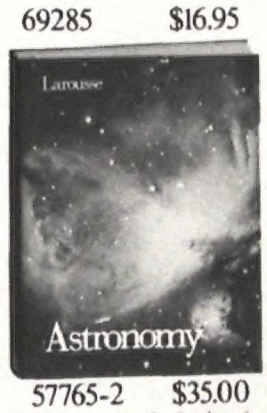

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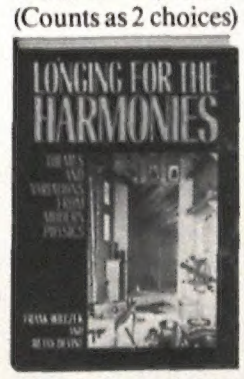

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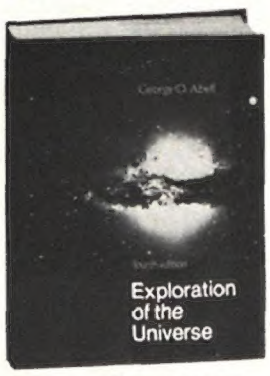

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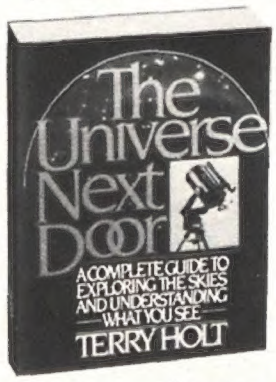

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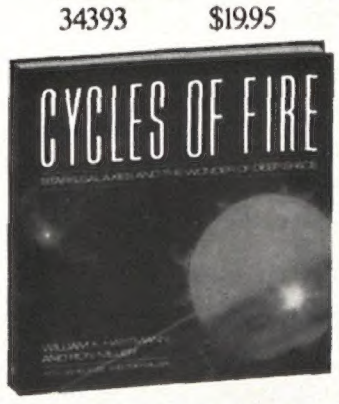

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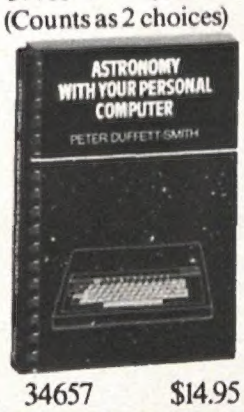

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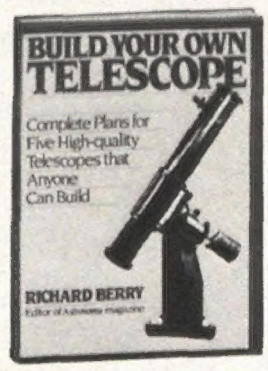

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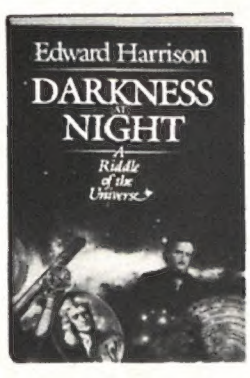

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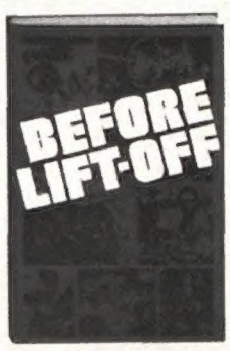

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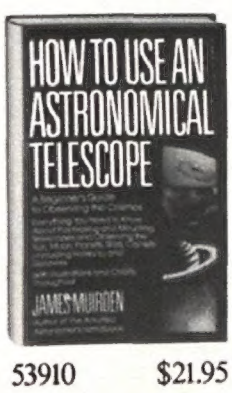

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Air & Space 8-9/88 L-CG3

August/September 1988
Volume 3, Number 3

AIR & SPACE
Smithsonian

Contents

Cover: *Tony Fontes' photo demonstrates that the view beneath a seaplane is spectacular—whether or not it's flying.*

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Viewport

The *Enola Gay*

Since coming to the National Air and Space Museum a year ago, I have been receiving a steady stream of letters concerning the *Enola Gay*. The *Enola Gay* is the B-29 bomber that dropped the first atomic bomb, devastating Hiroshima, all but ending World War II, and changing the face of warfare for all time.

Most of the letter writers ask why the airplane is not displayed in the Museum. Some are veterans, men who risked their lives during the war. They wonder whether the Smithsonian Institution is deliberately keeping the *Enola Gay* from public view, perhaps in an attempt to rewrite history. Others urge that we refrain from exhibiting the bomber, believing that any display of the airplane could be interpreted as a tasteless flaunting of American might.

The controversial airplane became part of the Smithsonian collection nearly four decades ago. Named after the mother of Colonel Paul W. Tibbets, the pilot who flew the Hiroshima mission, the *Enola Gay* was still flyable when it went into storage at what is now Chicago-O'Hare International Airport. During the Korean War it was moved to Andrews Air Force Base near Washington, D.C. At the time, the National Air Museum, precursor of the National Air and Space Museum, had a small staff, little funding, and apparently no other means for properly caring for the airplane. Kept outdoors, the *Enola Gay* deteriorated badly.

In recent years, the bomber's fortunes have improved. It was taken apart and moved once again, to be restored at the Museum's Paul E. Garber Preservation, Restoration and Storage Facility in Suitland, Maryland, just outside Washington. Tens of thousands of visitors who have come to the Garber Facility during the past two years have been able to watch the painstaking restoration process. (Daily tours can be arranged by calling the Museum tour scheduler two to eight weeks in advance at (202) 357-1400 between 9 a.m. and 5 p.m., Monday through Friday.)

Earlier plans had called for the bomber to be far more accessible. When the Museum building was conceived, there was to be an exhibition area large enough to accommodate the *Enola Gay*'s 141-foot wingspan. Limited funding, however, dictated a smaller structure. In the existing building, the bomber would just fit, but would block access to other galleries, preventing exhibit changes.

We now hope to have the airplane restored in time for display at an extension to the Museum currently planned for one of the Washington-area airports. Bills to authorize that extension have been introduced in both houses of Congress. At the new facility, other airplanes and spacecraft too massive to be brought to the Museum on the Mall would also be exhibited. One of these is the NASA shuttle *Enterprise*, now housed at Dulles International Airport, near Washington.

The *Enola Gay* will be displayed in a setting that will recall the history of strategic bombing in World War II. As distinct from tactical bombing, which was designed to destroy specific military targets, strategic bombing was meant to break an enemy's overall ability to respond militarily. It was aimed at eliminating critical resources, such as ball bearings or gasoline, thereby paralyzing the enemy, or at wreaking enough havoc to break the will of a nation. The B-29 has been called the ultimate realization of the strategic bomber in World War II.

The practice of strategic bombing has raised many questions that have been debated ever since the end of World War II. These issues are critical, because the threat of war has never entirely left us. We need to ask: How effective were the raids militarily? Did the cost to the enemy actually exceed the cost of losses to the bomber command? And, above all, how high were the losses in civilian lives?

The vocabulary of war is now different. No longer do we talk of "thousand-bomber raids" and "carpet bombing." Instead, we debate "mutually assured destruction," "nuclear winter," and "megadeaths." Otherwise little has changed.

—Martin Harwit, Director, National Air and Space Museum

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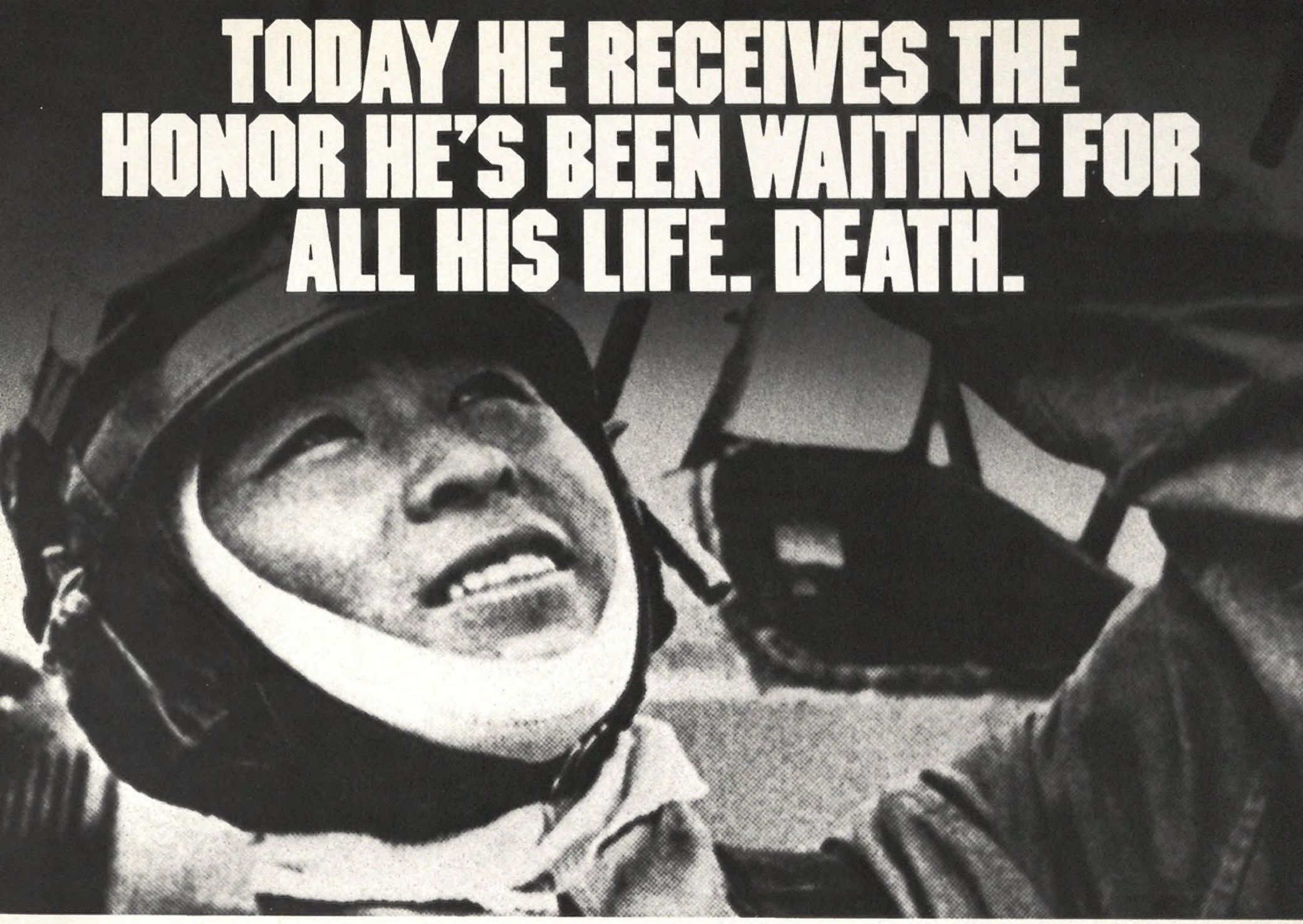

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Letters

The Bomber Debate

In "Why We Don't Ban the Bomber" (June/July 1988), Fred Reed obviously took his thesis from the position of the Union of Concerned Scientists, as he referred to its mouthpiece, John Pike, in his article. It is apparent that he knows very little about the purpose of the manned bomber.

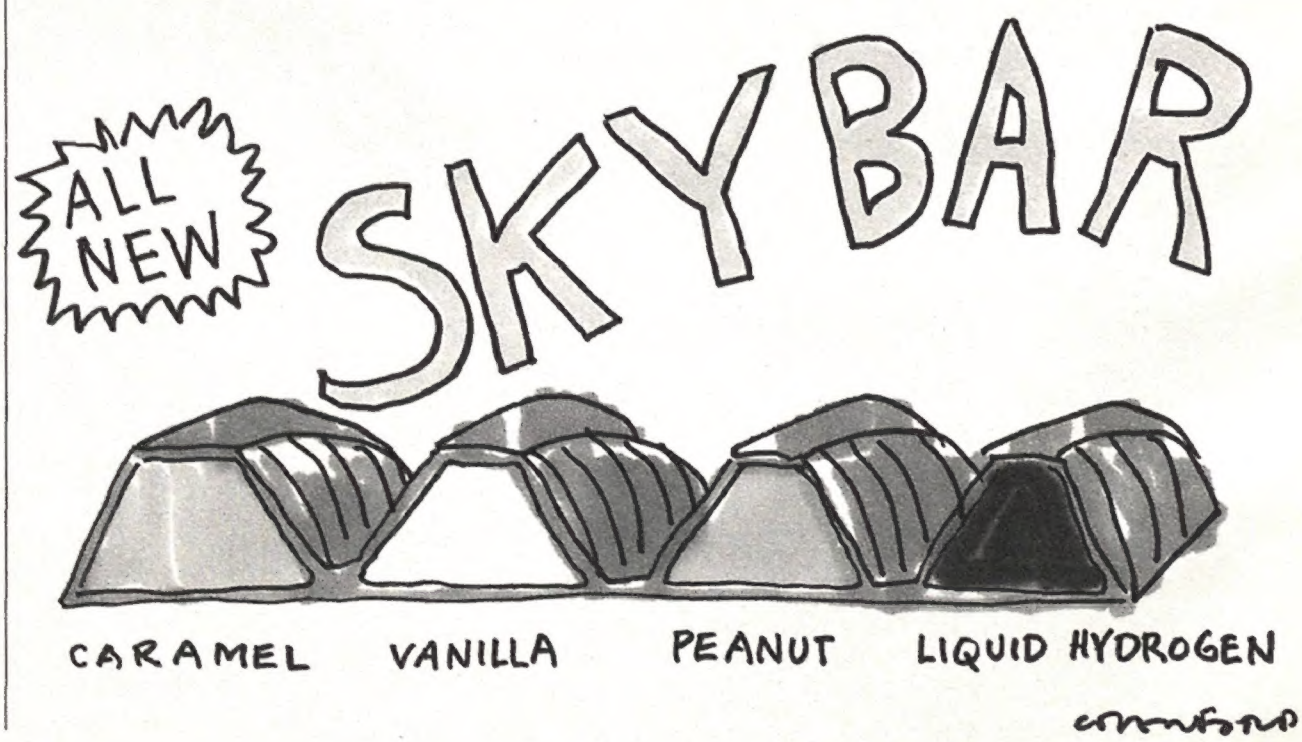
To begin with, the use of the manned bomber is not limited to nuclear war with the Soviets, although that is one possible use. The B-52 was designed for that purpose but was used with great effect by President Nixon in Vietnam.

The B-1 was required as a replacement for the B-52, which is essentially worn out. It is available for situations similar to that in Vietnam if we ever face one. It can be used in a conventional as well as a nuclear war. It has electronic penetration aids that will allow it to penetrate Soviet airspace, while the Stealth bomber is able to escape detection by radar.
E.J. Bataille
Walnut Creek, California

I do not find *Air & Space/Smithsonian* to be an appropriate forum to discuss strategic warfare. However, if a discussion of the utility of manned bombers in strategic warfare was to be undertaken, a balanced article should have been presented. Mr. Reed's attempt to discredit advocates of manned strategic bombers by portraying them as paranoid and parochial descends into demagoguery. This does the general public a disservice.
Mark Ostrowski
Farmington Hills, Michigan

Fred Reed chose to overlook two important scenarios in his attack on manned strategic bombers. First, "strategic" doesn't always mean "nuclear." I'm sure a conventionally armed B-1's chances of survival over any enemy's territory far exceed those of a B-52. Secondly, I'm not convinced that American bombers orbiting their country during a crisis wouldn't stop the Soviets from launching their missiles. If that were true, why are they developing their own Backfires and Blackjacks?
Jeffrey Lathrop
Kansas City, Missouri

Having been a subscriber to *Air & Space/Smithsonian* for about a year, I would like to congratulate you on what I believe has been an improvement in the magazine. The book reviews have been generally good, but I especially enjoyed the June/July 1988



issue. "Corrigan Revisited," "Hover Story," and "The Schneider Trophy" were all excellent, but Fred Reed's "Why We Don't Ban the Bomber" was more than just refreshing—it was important. Let's have more of Mr. Reed's thoughtful analysis.
Bartlett Gould
Newburyport, Massachusetts

Destination Mars?

John Logsdon wrote in his essay "Resist the Pull of Mars" (April/May 1988) " . . . the moon, not Mars, is the next logical locale for developing U.S. space capabilities." A wider approach would seem to enrich the American space program more. A lunar base, an outpost for a further push into space, is naturally desirable. But a space program limited to but one project would postpone, perhaps for decades, the exploration of Mars and other planets of the solar system.

The moon is a well-studied place: it was observed by automatic probes, roamed by the Soviet moon rover, and visited by American astronauts.

Exploration of Mars, on the other hand, could produce unexpected results by changing our notion of the solar system and making a giant scientific and technological leap. A manned flight to Mars is feasible in our age of high technology.

Exploration of Mars is prominent on the Soviet space program until the year 2000. This summer the Soviet Union will launch two probes to study Phobos, a satellite of Mars. In 1994, there will be a number of Martian studies by orbital probes—satellites and balloons in the planet's atmosphere, rovers, weather stations and landers, as well as a subsatellite to be dropped from the spaceship to accompany it in flight. Experts expect that between the years 2000 and 2005 Mars will be roamed by large rovers with long service lives and ranges of up to 620 miles. A manned expedition to Mars will be ready by 2015 to 2020.

The Soviet program does not overlook the moon. The latter half of the '90s will see the launch of a satellite to photograph the entire surface of the moon. There are plans for a sample-return mission on the dark side and a permanent research station equipped with mobile means.

Deep-space exploration is nevertheless in the focus. Exploration of the moon and Mars calls for considerable outlays, which makes imminent one's choice between the two to the detriment of the other. The only way out is U.S.-U.S.S.R. research cooperation, sharing experience and discoveries. Then the question "The moon or Mars?" can be answered: "Both, by the U.S. and the U.S.S.R."
Andrei Baidak
Novosti Press Agency
Moscow, U.S.S.R.

Adjective Horror

It is a pity that an otherwise perceptive article such as Greg Freiherr's "Balloons Over Venus" (June/July 1988) should be marred by the use of that wretched "word" *Venusian.* As ugly and grammatically incorrect as *Earthian* or *irregardless,* its use stems from the abject terror of prudes confronted with the correct adjectival form, *Venerian.*

Air & Space/Smithsonian, as the journal

of record for space history, should resist the pressure to corrupt the English language in an effort to avoid controversy. The connection between the Venerian atmosphere and venereal disease is as tenuous and unimportant as that between the lunar surface and lunacy.
Victor Koman
Long Beach, California

What's in a Name?

The article "The Black Box" (June/July 1988) mentions a lack of certainty as to the origin of the term "black box." The term has long been used, and is still used today, as a catch phrase for an aircraft's electronic components. Nearly all avionics are encased in black metal boxes.
Ron Sirull
Tampa, Florida

Editor's reply: it was the specific use of the term in the mass media to describe flight data recorders to which the author referred.

Volunteering Information

I wish to clarify a comment made in "One Hundred Hawks for China" (April/May 1988) about the American Volunteer Group. After our contract was completed on July 4, 1942, we were not inducted into the U.S. Army Air Forces. Five pilots and 29 groundmen volunteered to go back into the service in China. Other members of the AVG went home to the states or to work

"It's always that way—whenever you want to get someplace fast, it seems as if the universe is rapidly expanding."

for CNAC airline in China. Later, some volunteered to go back into the service. Because of our experience many got jobs with defense contractors, thereby becoming exempt from the draft.
Donald L. Rodewald
Lake City, Colorado

Wronged Robin

Did Phil Cohan ("Wrong Way Corrigan Revisited," June/July 1988) bring out a truism? I refer to Corrigan's statement "Got no use for writers. They *never* get it right." The writer called Corrigan's airplane a "ramshackle nine-year-old Curtiss Robin." But Corrigan was a professional welder and mechanic, and the Robin was completely overhauled. It disturbs me when an airplane is criticized simply because it's old. Many of these airplanes are flying today. Any antique airplane that can be located is sold (even basket cases) at high premium to enthusiastic antiquers who fly them with pride. Once these airplanes are restored, they are in A-1 condition, probably better than contemporary airplanes because they were put together with TLC.
Francis Rourke
Bartlesville, Oklahoma

Don't Try This at Home

It was with a mixture of nostalgia and dismay that I read "Burning Ambitions" (Flights & Fancy, April/May 1988). Like so many youngsters with a zeal for things that fly, I experimented with making my own rockets. Also like most youngsters, I never realized that I was doing something quite dangerous. Fortunately, I was blissfully ignorant of the best fuel mixtures and managed only to hurt a patch of grass in my best friend's backyard. Therefore, I question the wisdom of printing names of chemical compounds for manufacturing fuels, even in this fanciful manner. There are still zealous youngsters who will experiment with "basement bombing," all the while believing that accidents happen only to the other guy.
Lawrence Bercini
Chicago, Illinois

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Native American Aerospace

Yvonne Gensurowsky/Stansbury, Ronsaville, Wood Inc.

For the Nevada Paiute Indian tribe, selling handiwork to tourists is vanishing as a way to bring in income. With help from Uncle Sam, the tribe has established a plant called Nuwuvi Composites Technology in the desert near Las Vegas and is fabricating aircraft components. "We have to join the economy," explains Paiute council member Carmen Patrick. "We don't have a lot of resources here in the desert."

The idea for the plant was conceived in the early 1980s, when tribal leader Billy Frye persuaded the Paiute council to launch a company that would use semi-skilled labor to assemble high-tech products, such as circuit boards. Vincent Lachelli, a senior member of the Washington, D.C. law firm that represents the tribe, talked with some of the officials at Boeing who award contracts to private-sector companies and then recommended the tribe undertake the potentially lucrative production of aerospace composites. Lachelli secured funding from the government's Administration for Native Americans to help the Paiutes develop a business plan. But most of the funding came from the tribe itself. The members put in some $900,000 of tribal money, erected a 5,000-square-foot building, and bought an autoclave—a pressurized oven for curing composites.

They also brought in two outsiders: a manager from Seattle who had given courses in composites fabrication for Boeing at a community college, and a specialist in small business startups. When both began to have frequent disagreements with the tribe's business manager and other Paiute leaders, progress ground to a halt, and soon money became scarce. The council asked the two advisors to stay on as volunteers until business picked up. They declined and left the fledgling company.

In search of a new manager, John Waller, another attorney from the Paiute tribe's Washington law firm, met Douglas Finch at a composites tradeshow and asked him to take over the operation. Finch, an MIT graduate and a project manager at a Los Angeles composites firm, jumped at the chance. "It was a very exciting opportunity," he says. "It's a challenge at age 27 to jump in and run a company when

its equipment is just sitting there."

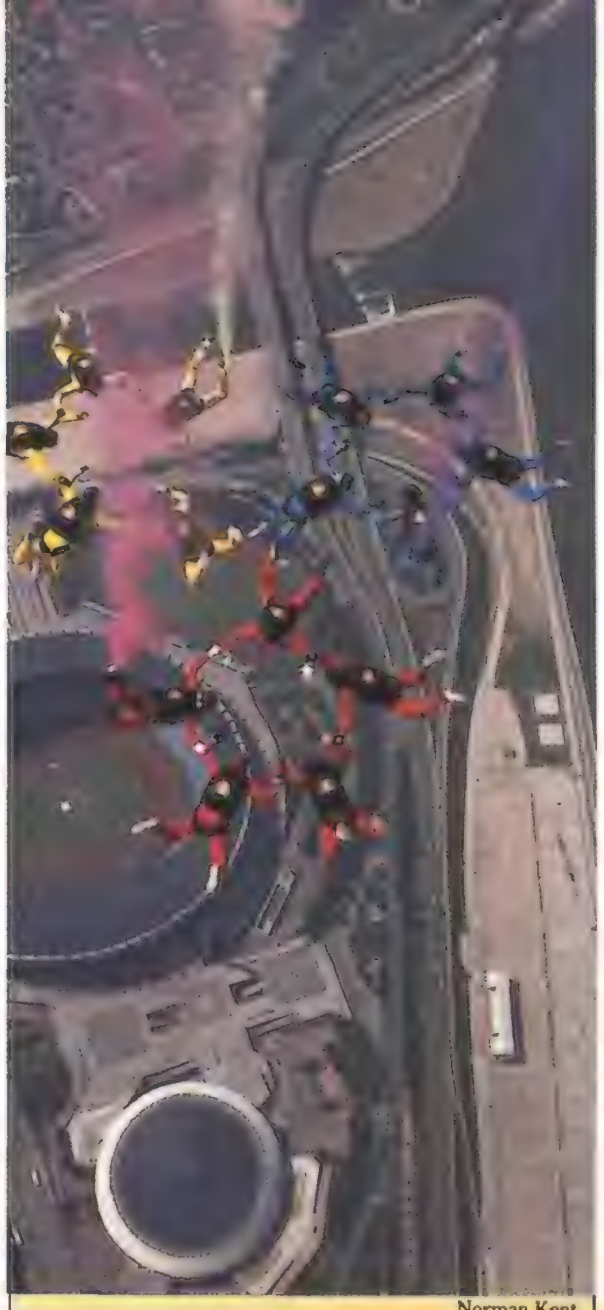
In April 1987 Finch and Mark Spatz, an MIT colleague, set up a two-month training program in composites fabrication for 25 tribe members. "It's very hands-on," says Finch. "You don't need an engineering background to do the labor; it's like laying up cloth." To bring in quick cash, Finch sold autoclave time to local aerospace companies. He set about lining up customers and landed a manufacturing contract with Kitt Peak National Observatory in Arizona. One year later, Nuwuvi had seven employees working on $200,000 worth of contracts.

Attorneys Lachelli and Waller, who initially viewed the composites plant as a pilot project, had persuaded the Economic Development Administration to increase funding if the plant showed signs of success. Early this year, the agency agreed to add $1 million. While major aerospace firms are required by law to award a certain number of contracts to minority-owned businesses, Finch says such laws merely allowed Nuwuvi to get its foot in the door. The plant then had to prove itself on the basis of cost and quality. According to Finch, the plant's desert location and paid-for autoclave mean low overhead. Nuwuvi, now building a 15,000-square-foot plant, expects to double its workforce and revenues by December, fulfilling "a tribal ambition for self-sufficiency and stable employment," the company's original purpose.

—T.A. Heppenheimer

Space Ed

Blushing beneath her freckles, Cherie Hampton stood before fellow Girl Scouts amid memorabilia from U.S. and Soviet spaceflights. Bill Streeter, chief of education at the Space Center in Alamogordo, New Mexico, held up a spacesuit outer garment worn 14 years ago by astronaut William Pogue aboard Skylab.



Norman Kent

World champion parachutists practice an Olympic ring formation over the Main Olympic Stadium in Seoul, South Korea. Skydiving will be an exhibition sport in the summer games this September.

"You're pretty tall," he told Hampton. "It'll fit you okay."

Hampton was one of about a hundred nine- to 12-year-old scouts at the Space Center one Saturday last February for the one-day program to earn Aerospace Badges. As Hampton wiggled into the white nylon coveralls, Streeter explained the mechanics of the spacesuit. "There's more to it than what she's wearing," he said, explaining that cooling and insulation layers are worn beneath the outer garment.

While Hampton pulled on boots once worn by John Young and Fred Haise, someone asked the inevitable: "What if you have to go to the bathroom?" Streeter described the garment that holds body waste. "It's called a diaper," he said, eliciting giggles from the small sea of forest green.

Hampton struck a model's pose and grinned. Streeter lowered a helmet over her head and asked, "What if you had an itch? Try to scratch your nose." She made a face. He showed how astronauts can scratch their noses with a probe or drink from a squeeze can through a port in the helmet.

"What if you had to sneeze?" one scout asked. "Well, she'd have to clean her helmet after she took it off," Streeter explained, prompting a collective "*Ew,* yuck."

More than 300 members of the Rio Grande Girl Scout Council have earned badges at the Space Center, which began offering the clinics last October. The hillside complex overlooks the White Sands Missile Range, where the Army launched its first space probes in the 1940s.

The scouts' clinic began with basic aerodynamics. The girls learned how wing shape relates to speed and how the SR-71's fluted fuselage helps make it the world's fastest aircraft. They assembled paper and plastic aircraft models with functioning ailerons, elevators, and rudders, which they later flew outside. Using a model of the shuttle, Streeter explained solid rocket boosters and maneuvering thrusters. "I learned the most dangerous part of the space shuttle is the rocket boosters," said Barbara Newman, "because once they are lit you can't stop them."

The tour included a planetarium lecture, a Hall of Fame museum visit, and a lecture by aerospace medicine pioneer John Stapp. Astronomer Arthur Barton introduced the planets and explained their chemical compositions. "Jupiter—this planet smells like an 88,000-mile-wide rotten egg."

The girls watched a local rocket club fire model launch vehicles, then unpacked their bag lunches and ended the day at the center's Omnimax theater with a showing of the IMAX film *On the Wing.*

—Harry Weisberger

After They've Seen Paree

Most pilots know Brown Field, a quiet airport south of San Diego and just a stone's throw from the Mexican border, as a place to clear Customs. But in mid-May, Brown Field had its moment in the spotlight when it hosted Air/Space America 88, a new airshow. The show's organizers wanted to provide an alternative to the huge airshows in Paris and in Farnborough, England. They'd heard from U.S. aerospace company representatives who returned from Paris complaining about poor treatment at the hands of French airshow officials; some said Paris stacks the deck in favor of the home teams.

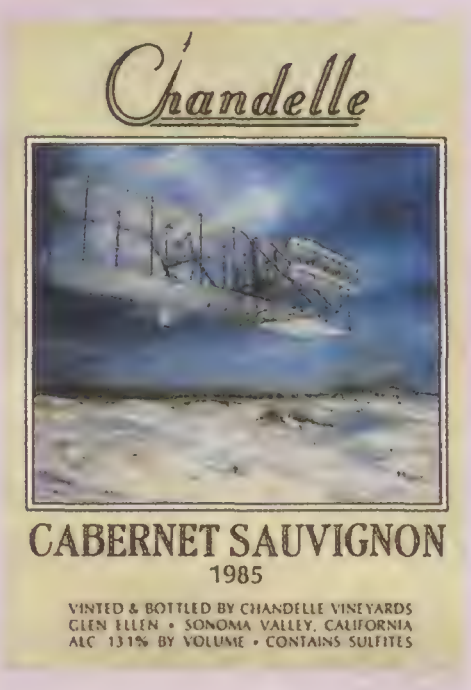
But diminishing enthusiasm for the big airshows among U.S. aerospace firms has more complex causes, one of which is the high cost of the shows for the actual value of business done at them. As the selling of expensive airplanes and spacecraft becomes more complicated, it takes more than an afternoon's glass of wine to clinch a deal.

The Grapes of Hap

"Some people get the wrong impression that I've got Falcon Crest in the backyard," says Robert Arnold, referring to the 40 acres his family owns in California's Sonoma Valley wine country. Arnold's grandfather, General Hap Arnold, chief of the U.S. Army Air Forces in World War II, bought the land when he retired in 1945. Late next year the general's son Bruce, a retired Air Force colonel, and Bruce's son Robert hope to start their own vineyard on it.

The younger Arnolds got into the wine business a few years ago. But before planting their own grapevines, which take up to five years to produce, they are testing the market with Chandelle wine, currently produced and bottled under contract at another winery. Bruce came up with the name Chandelle, an aerobatic maneuver that combines a 180-degree turn with a gain in altitude. To Robert, it was also a metaphor for a career change—he left the computer sales business to get Chandelle off the ground. "Besides," he says, "would you want to drink a wine called Slow Roll?"

Chandelle offers a cabernet and a chardonnay in bottles bearing labels designed by aviation artists. Bill Reynolds' "12 Seconds at Kitty Hawk" depicts the Wright *Flyer* over the dunes; "Gathering of Eagles," by *Air & Space/Smithsonian* contributor Paul Salmon, is a montage of five World War II aircraft. Buyers can have a message inscribed on a second wing-shaped label.



"'Wishing You Blue Skies' is a really popular one," says Robert. To date Chandelle wine has been available only at a few military bases, at military reunions, and by telephone order. "Since the beginning of the year we've shipped a couple hundred cases," Robert says, "and bottled more this week. It looks like for the moment we're onto a pretty good idea."

Robert says the joys of running Chandelle come largely from the stories that accompany orders. "One fellow," he says, "was part of the group that flew B-17s into Pearl Harbor on December 7, 1941. My grandfather had seen them off at Hamilton Field that evening."

Buyers receive by mail issues of *The Chandelle Courier*, written and edited by Robert and his wife Mary Evelyn, a Chandelle co-owner. The newspaper contains information about ordering wine as well as anecdotes from Bruce and Robert about growing up in the Arnold households. "Instead of cars or baseball, we dreamed of T-2s, Jennys, and DHs," Bruce writes.

A business built on memories also requires attention to the future. Robert is planning two more labels this fall, probably a Navy Air label with a Corsair and another Army Air Forces label. And he is certain The General would approve.

"The man did everything he could think of to get people to like aircraft. He got all the movie stars to come out to March Field and watch flybys. I think this would appeal to him a lot."

—Bob McCafferty

Despite such obstacles, the founders of Air/Space America promoted their exposition as one intended to project the U.S. aerospace industry as the world's leader. By opening day, Brown Field's acres of dust were transformed. The airshow began on May 13 with exuberant backslapping and congratulations among the founders, politicians, and public figures. Vice President George Bush showed up along with California Governor George Deukmejian to extol the virtues of U.S. aerospace industries.

The organizers had hoped for the presence of the local industry heavyweights—Boeing, Lockheed, McDonnell Douglas—but the heaviest weight in attendance was the Soviets' Antonov An-124, the world's biggest transport aircraft. Other international participants included China Great Wall Industry, which sells launch services. Sweden promoted itself from a blue and yellow booth. Even Argentina had a snappy exhibit. Some U.S. giants showed up—General Dynamics, Hughes Aircraft, Martin Marietta—but not with the heft they wield at Paris.

U.S. industry was typified by companies that supply the big guys with rivets and fasteners, lubricants, and all sorts of electronic components. By Monday, however, the supplier reps may have been a little lonely. The weekend show had drawn huge throngs, but the weekdays were set aside for "trade days"—industry people only. Though no one was counting, an army of volunteers, each wearing a badge and carrying a two-way radio, may have outnumbered the visitors. Dozens of portable toilets arrayed throughout acres of empty parking lots gave the place an eerie quality. Easter Island might have looked like this if the ancients had used fiberglass instead of stone.

In mid-afternoon, the Confederate Air Force made one of its patented arrivals with some World War II bombers. A few people left the huge white tents that housed the exhibits—it had gotten pretty hot inside—to watch the warbirds pass low over the runway, circle a few times, and land.

On Tuesday morning, groups of students arrived on buses and began what appeared to be guided tours. One group stopped at a very large NASA exhibit at which the benefits of space exploration were portrayed—cordless electric tools were one example of a space spinoff. While the students listened to a speaker, a group of Soviet engineers on the other side of the NASA exhibit was quizzing a man who was shooting empty soft drink cans into the air by placing them atop a coil and pressing a hidden button. The coil turned out to be a

A new cabin control system for Boeing's 747-400 jumbo jetliner uses all-digital technology to perform a wide range of passenger service functions previously unavailable. The Advanced Cabin Entertainment and Service System (ACESS), designated the APAX-140, extends the application of digital multiplexed techniques to such functions as cabin interphone, lighting, and advisory signs. Other features include an interactive, two-way capability that allows passengers to communicate back to a central computer for in-flight ordering of specific goods and services, and a self-test function that monitors and records faults while in flight. Hughes Aircraft Company, supplying multiplexed passenger entertainment and service systems since 1970, designed and built ACESS for Boeing.

Carried aboard a new satellite, positioned to detect storms threatening the East Coast, are two experiments. The Geostationary Operational Environmental Satellite (GOES) H, designed and built by Hughes for the National Oceanic and Atmospheric Administration, includes a space environment monitor (SEM) and an experimental receiver. The SEM assesses magnetic field strength and direction, solar x-ray fluctuations, and particles in its vicinity that make up solar wind and radiation belts around the Earth. The receiver will be used to aid in international search and rescue missions by monitoring radio distress signals from troubled ships or aircraft throughout most of North and South America. GOES H is in geosynchronous orbit above the Atlantic seaboard.

A newly developed system significantly speeds up the measurement of digital data generated by modern radars. The Automated Radar Monitor (ARM) system uses a computer and special interface hardware. It replaces expensive, time-consuming manual special test equipment (STE) hardware panels currently used. ARM can collect high-speed digital radar data, analyze it, and display it on several computer terminals simultaneously. The cost of the ARM system, developed by Hughes, is approximately one-third that of the STE it replaces.

The United Kingdom Infrared Telescope (UKIRT) in Hawaii was the first to use a new infrared focal plane array, which has caused a technological revolution in infrared astronomy. The Hughes-built microchip "sandwich" provides sharp, fast infrared images of our solar system and the galaxies. Astronomers can now obtain a better look inside mysterious clouds of dust and gas, known as nebulae, to learn more about the life cycle of stars. The array also produces, for the first time, fine-grain infrared images of objects within nebulae that were previously hidden.

A broad spectrum of technologies, many of which grew up within the past five years, are represented in the products of Hughes' Industrial Electronics Group. Six divisions and two subsidiaries, each operated like a small high-tech company but backed by resources of its multibillion-dollar parent, offer career benefits to qualified engineers and scientists. Advancing technologies such as microwave and millimeter-wave communications, silicon and GaAs solid-state circuitry, fiber optics, and image processing equipment are pursued in facilities located in many of Southern California's most desirable coastal communities. Send your resume to A.T. Moyer, Hughes Industrial Electronics Group, Dept. S4, P.O. Box 2999, Torrance, CA 90509. Equal opportunity employer. U.S. citizenship required.

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HUGHES
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new device for removing ice from airplanes in flight. A capacitor is charged up and when the button is pushed, the current from the capacitor discharges through the coil, causing it to expand with a wham that jars the ice loose—or, in this case, sends the soda can about 20 feet straight up.

The Soviets used gestures and a few English words to convey their questions, and the NASA man responded by scribbling a quick schematic on a notebook page. When he finished, the Soviets nodded enthusiastically and exclaimed, "Ah! Ah!" Then they moved on to the next exhibit.

After the event, Air/Space America 88 organizers reported that paid public attendance during the two weekends was only half of the 280,000 they had hoped for. Still, they are already at work lining up exhibitors for the 1990 show.

—George Robinson and George C. Larson

The Spaceport State

Florida, long the main jumping-off point for the nation's space ventures, now wants to attract business travelers.

Standing near the site where the United States entered the space race 30 years ago with the launch of Explorer 1, Governor Bob Martinez declared on March 25 his state's intention to create the nation's first commercial spaceport. "Spaceport Florida," he told an audience of aerospace executives and legislative leaders at Cape Canaveral Air Force Station, "will be America's private-sector highway to space."

The highway is expected to draw heavy traffic. There is a $2.3 billion backlog in communications satellites and other civil payloads, according to state officials, and demand will grow even after the space shuttle is flying again. "Our goal is to launch one commercial mission each month," Martinez said, who went on to claim that each launch could gross $45 million.

Fueled by such prospects, Florida is spending $500,000 to identify the best route to follow in establishing the facility. The study, to be completed early next year, will determine "what the ideal spaceport should look like," says Chris Shove, an economic analyst with the state's commerce department and director of the project.

"Since we've got the opportunity to design a spaceport that will remain useful for decades," Shove says, "we want the study participants to look at some of the technological changes headed our way, such as advanced launch vehicles and new generations of computer systems. But we stress that this is a 'can do' project, not just an exercise to see if we should move ahead. We *will* have a spaceport."

What might come first is a facility that will use some of the abandoned launch pads at the Air Force station, along with existing tracking systems and support services scattered throughout the area. If there are no delays—and Shove chuckles at such a prospect—a symbolic launch, perhaps a small Scout-class rocket, might be made in 1992.

But once NASA resumes its launch activities, commercial users could easily be squeezed out over the next five to 10 years. Eventually, Shove says, another spaceport may be needed, one removed from federal sites. New facilities might even be built at sea. "Italy has launch platforms off Kenya," he says, "and the water stretching for several miles off Florida is only about 40 feet deep, so this isn't really such a Jules Verne kind of thing."

The spaceport commission is already examining various financing options. "One possibility," says Shove, "is to establish the spaceport as a quasi-governmental not-for-profit corporation much like today's airport or seaport authorities. The corporation would be able to sell tax-free bonds, issue stock, charge user fees, receive grants from the federal government and corporations, even levy certain taxes."

The cost is still uncertain, though "certainly substantial," Shove acknowledges. "But many authorities estimate that the private-sector space industry will be worth $60 billion by the year 2000. So becoming a major player will be well worth even a hefty price tag."

Space, as the Sunshine State sees it, is destined to become a major business center. "And the places that develop the infrastructure required to get to space," says Governor Martinez, "will become the focal point of that industry forever."

—Tom Burroughs

No, the OTHER Door

Late in April the Federal Aviation Administration issued an airworthiness directive calling for new door labels in de Havilland DHC-8-100 commuter aircraft cabins. "This amendment," the directive reads, "is prompted by reports of passengers mistaking the airstair door operating handle for the means of gaining access to the lavatory. This condition . . . could lead to inadvertent opening of the airstair door and consequent depressurization of the airplane."

WPBT-2

The Hustler

On some 200 Public Broadcasting TV channels, most nights end with a balding man walking down a runway suspended in deep space. Then, accompanied by goofy electronic music, Jack Horkheimer launches into a five-minute spiel on what the stars and planets are up to that night, pointing out key players on the celestial backdrop.

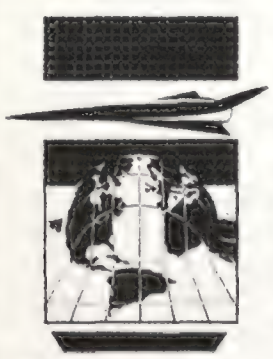
"Jack Horkeimer: Star Hustler" is produced at the Miami PBS affiliate WPBT-2. "I call what I do 'hustling,' " Horkheimer says, "because I have to win my audience over in a very short period of time." His hard-sell technique has paid off: the show went national in 1985 and now has an audience of both science and science fiction fans who send Horkheimer thousands of letters each week.

The star hustler also sold the locals on the Miami Space Transit Planetarium. Named executive director in 1967, Horkheimer says his marketing strategy has made it one of the few planetariums in the country to run in the black. "I kicked a lot of sacred cows," he says. "I took what most people thought was a scientific institution and turned it into a popular place where people brought dates."

Horkheimer also took the pop astronomy approach to "Star Hustler." Titles have included "Shower With a Friend: How to Find a Meteor Shower" and "Double Your Pleasure, Double Your Sun: Would Our Solar System Come Apart If We Had Two Suns? Would a Florida Tan Be a Very Dark Brown?" The show airs near midnight, says Horkheimer, to encourage watchers to make a quick trip outside to look at what he's just described before going to bed. "My colleagues say I'm the first to put drama into astronomy shows," he says, "but I realized a long time ago that what I liked dramatically seemed to sell. And I believe that when people become interested in their environment, it expands their overall awareness. They become less chauvinistic and self-centered—their world opens up and they become more conscientious about it."

Horkheimer, a stargazer since childhood, seems to have found his calling in the show's mixture of entertainment and education. "Each year on the first day of summer I ask people to go out just before dawn and watch the sun rise—to see what a star rise over a planet really is," he says. "And people write and tell me, 'I've never experienced a sunrise before that morning.' Through this little show, they've rediscovered the beauty of the universe."

—Michael Rozek



Kim Barnes/Stansbury, Ronsaville, Wood Inc.

A Tree Grows in Cheyenne

Terry Rogers, a Cheyenne, Wyoming homeowner, went out on a limb when he refused City Hall's order to trim his 48-foot cottonwood tree, considered a navigational hazard to air traffic. In February 1987 the city began fining him $200 a day. Rogers vowed to appeal, claiming that the airspace above his property belonged to him.

When the Wyoming Supreme Court upheld the legality of the fine in December 1987, Rogers took his case to the U.S. Supreme Court. Last April, however, the justices refused to hear Rogers' appeal, in which he maintained that the city's ordinance limiting the height of structures near Cheyenne Airport is unconstitutional because it takes private property without just compensation. Though he gave in and trimmed the tree, he now could owe the city as much as $19,000 in fines and has little hope of winning a separate civil suit that he filed against Cheyenne for punitive damages.

"I thought that when I bought this property it belonged to me. But it doesn't," Rogers says. "You tell me that we're better off than the Russians? You've got nothing but a police power in this country."

The controversy developed when the Federal Aviation Administration, during a routine inspection of Cheyenne Airport, found that Rogers' cottonwood, 300 feet from the approach end of Runway 30, penetrated 25 feet into the airport's airspace. The city ordered Rogers to take 25 feet off the top of the tree. Rogers claimed cutting it could kill it, which he said would reduce his property value by $2,000.

"It was a safety hazard," says John Wood, Cheyenne Airport manager. "Somebody could have gotten off the flight path and hit that thing. It was a *tree*, for crying out loud. He wanted to make a moral argument and take on the government over a tree." What Rogers ended up learning, it seems, is that money doesn't grow on trees.

—Phillip Swann

Update

Airshow statistics (Soundings, April/May 1988) show that California leads the nation in airshow production with 36 shows this year. Florida is second with 24, followed by Texas at 22. Delaware and Hawaii are the only no-show states. The International Council of Airshows says the average 1987 airshow attendance of 44,639 is up 17 percent from 1985.

The three-letter airport identifier for Sioux City, Iowa ("A Case of Identity," October/November 1987), under attack by state officials, will be changed. The Federal Aviation Administration has agreed that SUX is an unacceptable abbreviation for the facility.

The launch of the Hubble Space Telescope, scheduled for June 1989 ("Grounded," June/July 1988), may be postponed yet again, this time to avoid a period of intense solar activity in the second half of 1990. If the HST is launched in June, increased drag in Earth's outer atmosphere produced by "solar maximum" could require an early shuttle-assisted reboost of the telescope, straining NASA's backlogged schedule. The agency is also considering the alternative of placing the HST in a higher orbit.

"Suggested list prices" for Commander aircraft parts (Soundings, October/November 1987) have been dropped. Bob Buckley, president of Gulfstream Aerospace Technologies, says the company assumes market pressure will establish lower prices, benefiting operators of some 3,000 Commander aircraft.

Pioneer Venus 1, which provided the first radar map of Venus ("Balloons Over Venus," June/July 1988), completed 10 years of service last May; its useful life had originally been estimated as one year. NASA says the orbiter is still returning data on cloud cover and atmospheric conditions and has enough fuel to operate for another four years.

Ben Lexcen, designer of the winged keel that helped *Australia II* win the America's Cup ("Soaring on the Sea," February/March 1987) in 1983, died of a heart attack in Sydney, Australia, on May 1 at age 52. "He's a one-off," an *Australia II* crew member once said of Lexcen, a national hero in Australia. "There was a flash of lightning one day and there he was."

President Reagan showed little interest in a Soviet-U.S. Mars mission ("Resist the Pull of Mars," April/May 1988) during a June 8 press conference in which he announced his support of George Bush. Reagan claimed his efforts to improve U.S.-Soviet relations would be stymied if Bush did not succeed him but later added, "Incidentally, we've already sent a craft to Mars, as you know, [and] taken some pictures that make you wonder why anyone would want to go there."

—Patricia Trenner

Anniversaries . . .

Astronomical Society of the Pacific

Joseph Lockyer discovered the second lightest element, which he named helium.

1868

August 18 British astronomer Sir Joseph Norman Lockyer discovers helium. Using a spectroscope of his own design, Lockyer found that the sun's spectrum indicated a variety of gaseous elements. After studying a bright yellow line that he had never seen in a spectroscopic analysis of any Earth substance, Lockyer falsely concluded that the sun contained an element not found on Earth. It was not until 1895 that helium was detected on Earth.

1908

August 5 Farmer Arloch Wheeler attempts to fly from the roof of a barn outside Greenwich, Connecticut, on wings of wood and paper. Wheeler was believed to have become mentally incapacitated by the summer heat after working all morning in his turnip field. Two men noticed the farmer standing on top of his neighbor's barn with wings attached. With a cry of "I am Count Zeppelin!" Wheeler sprang from the roof and plunged into the Mianus River. When he was revived after nearly drowning, he had no memory of his stunt.

August 15 Philadelphia's first moonlight balloon party begins at 10:34 p.m. when a Philadelphia Aeronautical Recreation Society balloon is cut loose carrying two couples and a picnic. As the balloon ascended, the passengers used flashlights to signal "All's well" to the send-off crowd of 2,000. After reaching 10,300 feet and drifting 60 miles, the balloon landed on a Maryland farm the next day. *The New York Times* reported that the passengers were "burned brown as berries" by the sun. Said passenger Minnie Appelbach, "There was the absence of a feeling of motion at any time until we began to descend. The balloon simply seemed to be suspended between Earth and Heaven."

1909

August 2 After three years of bureaucratic inertia, the Army approves the purchase of its first airplane, a Wright Flyer. In 1905 the Wright brothers had written to the U.S. government, asking if it had any interest in their invention. The War Department's Board of Ordnance and Fortification responded that it did not grant financial assistance to inventors, even though the Wrights had not requested funding. Twice more the brothers were rejected by a board that doubted the existence of a flying machine. Finally, in 1907 Wilbur Wright made a presentation so impressive that the board solicited proposals for a military aircraft. Of those received, few merited serious consideration. One man wrote from prison saying he would produce an aircraft if the Army got him released. Another guaranteed a craft that could fly 500 mph.

Orville's test flights at Fort Myer, Virginia, in August 1908 were marked by some of the first tailgate parties, with spectators turning out by the thousands. A September 17 crash produced the first airplane fatality: Lieutenant Thomas E. Selfridge, Orville's passenger. Because the airplane was extensively damaged, it was not until a year later that an updated model passed the Army's requirements for military duty by staying aloft more than an hour with a passenger and flying 42.5 mph.

1911

September 1 At a county fair in Norton, Kansas, aviator J.J. Frisbie is goaded to his death. Frisbie, who had experienced a minor accident the previous day, doubted the integrity of his Curtiss biplane and decided not to fly. When fairgoers hooted and called him a faker, Frisbie changed his mind and ascended without difficulty, but when attempting a turn at 100 feet he lost control of the airplane and crashed. Frisbie's wife and two children were witnesses.

A similar fatality occurred three weeks later at a fair in Troy, Ohio, when Frank H. Miller, angered by a jeering crowd, decided to fly even though he had been having engine trouble with his biplane. As the band played a lively ragtime tune, Miller was heard shouting to his mechanic, "Let her go. I'll be glad when it's all over." At 200 feet the engine stopped and the airplane burst into flames.

The XC-120 and its detachable pod functioned as a tractor-trailer of the air.

NASM

NASM

Harriet Quimby was the first woman to fly solo across the English Channel.

September 4 Harriet Quimby, the first American woman to receive a pilot's license, earns $1,500 for entertaining 20,000 spectators at the Staten Island Fair on a moonlit evening. Quimby flew her monoplane four times around the fairground racetrack, nearly grazing the judges' stand on a low pass. In an effort to avoid the crowd while landing, Quimby hit a rut that bounced her airplane 10 feet; she narrowly missed a fence. After the landing, Quimby's mother rushed up and kissed her. "Oh mother," Quimby rhapsodized, "it was grand. I didn't feel like ever coming to Earth again. I think it was the effect of the applause."

1950

August 11 The Fairchild XC-120 experimental military transport makes its first flight. The all-metal, twin-engine XC-120 Pack-Plane was distinguished from other cargo craft by a detachable pod fuselage designed to accommodate a variety of payloads. One year later the Air Force decided that the XC-120 was not a suitable transport when flight evaluations revealed it to be basically unstable and difficult to fly at low speeds and in turbulence. Another problem was that the pod was difficult to attach in gusty winds and blackout conditions.

1953

September 1 The Air Force and Boeing publicize a joint program to test aerial refueling between jet-powered aircraft. The two-year-old program employed two modified Boeing B-47 bombers. The receiving bomber was fitted with a probe that jutted from its nose while the other B-47 carried a drogue-type refueling system. Boeing already had an operational tanker in its piston engine KC-97 Stratofreighter, but there was a demand for tankers that could keep pace with the new jet bombers and fighters.

CBS

Penny Robinson and Dr. Smith faced pistol-packing aliens on "Lost in Space."

1965

September 15 CBS premieres the science fiction adventure series "Lost in Space." The plot centered on scientists John and Maureen Robinson and their three children, who in 1997 leave an overpopulated Earth to colonize a planet near Alpha Centauri. The series, filmed at 20th Century-Fox Studios in Hollywood, starred June Lockhart of "Lassie" fame as Maureen Robinson and Jonathan Harris as the antagonist Dr. Smith.

1984

August 30 After three launch postponements space shuttle *Discovery* begins its maiden flight. During the six-day mission, astronauts released three communications satellites and, using a 50-foot remote-controlled arm, removed ice that had formed around water disposal nozzles on the fuselage. Mission 41-D also tested a new, improved toilet that used a porous plastic bag and a suction-type flushing system. The old motor-driven toilet had ground up solid waste so fine that it drifted into the cabin on an earlier flight.

. . . and Events

August 12–21
Wings of Eagles 1941 Warbirds Airshow and Fly-In. More than 70 World War II aircraft, including seven B-17s. Aviation film festival and art exhibit. At National Warplane Museum, Geneseo, NY, (716) 243-0690.

August 13 & 14
Prairie Aviation Museum's Fourth Annual Day at the Airport. Airplane rides, antique cars. At Bloomington-Normal Airport, Bloomington, IL, (309) 827-8039.

September 3–5
Labor Day Air Fair. Warbirds, airplane rides. At Whiteman Airport, Pacoima, CA, (818) 899-3816.

September 10
Airliners Northeast Convention. Sponsored by the Tri-State Airline Historical Society. Buy, sell, and trade airline memorabilia. At Vista International Hotel, Newark International Airport, Newark, NJ, (201) 447-1292.

September 10 & 11
The Great Hagerstown Air Show. Golden Knights, clown shows, and ground displays. At Washington County Regional Airport, Hagerstown, MD, (301) 739-1993.

September 15–18
25th Annual National Championship Air Races. Eight races a day and airshows featuring the Thunderbirds, wingwalkers, and Stardusters. At Stead Airport, P.O. Box 1429, Reno, NV 89505.

September 21
Mars reaches a distance of 36.5 million miles from Earth. It will not be this close again until 2003.*

September 22
Fall begins in the northern hemisphere with the autumnal equinox at 3:29 p.m. EDT. On this day, the sun rises due east and sets due west.*

**Call the Smithsonian's Earth and Space Report at (202) 357-2000 for recorded information on astronomical events.*

Organizations wishing to have events published in Calendar should submit them four months in advance to Calendar, Air & Space/Smithsonian, *National Air and Space Museum, Washington, DC 20560. Events will be listed as space allows.*

—Diane Tedeschi

The Last Flight of Zero Four Whiskey

Last February 21, a large, lovely aircraft concluded its final flight by landing at Dulles International Airport, outside Washington, D.C., for an indefinite stay. It was a Lockheed Super Constellation, an important new addition to the National Air and Space Museum's collection. One of the last great propeller-driven passenger transports, the Constellation was superseded by jet airliners in the 1960s. In the following account, the flight's captain, John Lear, looks back on 04W's last voyage.

It had been more than 15 years since I last flew a Connie, the gorgeous airplane that had sparked my initial interest in a career as an airline pilot.

After the Van Nuys tower cleared Lockheed 1104W, I taxied into position and called for max power. Copilot Darryl Greenamyer, the airplane's soon-to-be-former owner and something of an aviation legend himself, set the throttles for the four Wright 3350s.

With five crew members, four observers, and enough gas to get to Kansas City, we were well under the maximum gross takeoff weight. The airplane accelerated rapidly and took off into the cool, clear blue sky. "Positive rate—gear up!" I called. All eyes were glued to the gear lights that would confirm the successful retraction of the landing gear. Although the airplane had been fully licensed for the trip, we all breathed a sigh of relief as the lights assured us all was well.

I began a slow right turn and called for climb power. The controls felt good. They felt solid. They felt like, well, a real airplane.

I was by then a Lockheed L-1011 TriStar captain for a major charter airline. Although reaping the benefits of the "high tech" age, I couldn't help but feel a little twinge of the regret many pilots feel, a longing for the days when pilots were pilots and not "flight managers." Cockpits used to be filled with the smells of leather and sweat as well as the humming and purring of instruments and radios. Nowadays, cockpits are practically antiseptic. There are no oil or fuel smells; the seats are vinyl or whatever; the radio and instrument packages are operated remotely and stored in "electronic service bays."

As we droned up through Newhall Pass, the four 3,400-horsepower engines throbbing, I was reminded of the challenge of keeping those engines synchronized for passenger comfort. In today's jets, you can't even hear the engines from the cockpit.

As if the gods of aviation had prepared a special day for our journey, the sky was crystal clear and visibility was more than 100 miles all the way to the Mississippi. The Grand Canyon loomed ahead. Then Lake Powell. Monument Valley to our right.

Images of old and new—Constellation and Concorde—converge on runways at Dulles.

Up ahead, the Rockies. At our cruising altitude of 13,500 feet we gracefully weaved our way around the 14,000-foot snow-covered peaks.

Then came the expansive sprawl of the Great Plains. All was calm. All was peaceful. Everything on board was working except for the radios. But even that was something of a blessing, for without the constant staccato interruptions of airplanes checking in with air traffic control, my mind was free to wander. It returned to the start of my love affair with aviation.

It wasn't immediately obvious to me how a little boy who had spent a good part of every Christmas, Easter, summer, and Thanksgiving vacation getting airsick in the back of a Constellation droning back and forth between school in Switzerland and family in Los Angeles could have become so attracted to a career as an airline pilot. Maybe I simply realized that it had to be better up in the cockpit.

In those days you could sweet-talk the hostesses into letting you peek up front. The mystery of those dials glowing softly in the darkness over the Atlantic at night, the gentle throbbing of the engines, the stoic veterans who sat at the controls while you wanted to ask a thousand questions but, out of respect, held your peace—all kept me in their spell. "Hi," when I arrived and "Thanks!" when I left were about all I could manage. Someday.

"Someday" had been for quite some time now. I'd flown over 160 types of aircraft in

The Military Gallery

Robert Taylor recreates the excitement of another age in "Limitless Horizons."

over 50 countries, set 17 world speed records in the Learjet, and flown secret missions in Southeast Asia and Africa. There were names and places I would always remember—Khartoum, Mogadiscio, Saana, Long Tieng, Ban Huai Sai—and experiences I would never forget: the acrid smell of bullets passing through the cockpit, the incredible high of having lived another day to fly again.

Most of that was eventually given up for the security of family life and the comfort of scheduled runs in well-maintained airplanes. Kipling's words came to mind: "High hopes fade on a warm hearth-stone; he travels the fastest who travels alone." But there was no regret.

Kansas City was ahead. Gear down. Flaps. *Scrupp-scrupp.* The wheels kissed the pavement. Waiting to greet us were members of Save-A-Connie, a group working to have its own Connie flying by next summer. A quiet dinner and an evening of reflection passed quickly.

In the morning I called Washington Center to make the complicated arrangements for our arrival with less than a complete radio package. Darryl flew this leg—a man who at one time had more flying hours above Mach 3 than anyone but his copilot. A man who built his own private F-104 Mach 2 fighter from scrap parts. A man I was proud to be flying with.

It was afternoon, still clear with a few scattered clouds, as we melded in with the flow of other aircraft to Dulles. Many of the pilots who saw us probably couldn't even name this aircraft. But those who could undoubtedly remembered, as I did. Remembered when someday was still a distant day and the Connie was in her glory.

—John Lear

Horizons

Artist Robert Taylor is a man of few words. During his visit to the Museum in April, others did his public speaking for him. But Taylor could hardly be called a silent man, for he seems to have been placed on this planet solely for the purpose of painting the sea, the sky, and the ships and aircraft that venture outward and upward. His paintings speak volumes.

The frontispiece to "Horizons," an exhibition of Taylor's work appearing at the Museum through March 1989, is a rendition of one of Pan Am's Boeing 314 Clippers in the process of boarding passengers. The airline, which is sponsoring the show, began its trans-Pacific flights at its terminal on Treasure Island near San Francisco. In his portrait of one such moment in 1940 Taylor has captured the curious pale yellow light of a California afternoon and infused his work with a sense of expectation.

The real power in Taylor's painting is its ability to convey the mood of the era and, more important, of the moment within the era. "Although an airplane may be the most prominent feature, for me the main drama lies in the sky," Taylor once said. And the glowering fog that forms the backdrop to the big Clipper suggests the immense forces the airplane will soon encounter on its trip across the ocean.

Taylor researches his work as if he were writing a book. He uses models of the aircraft he's painting to render their proportions correctly in any flight attitude. And before he sits down to paint an air battle, he interviews the participants.

Probably the best known product of this approach is his "Duel of Eagles." Luftwaffe ace Adolf Galland is pursuing well-known British pilot Douglas Bader in the skies above France, where the two adversaries had frequent encounters. The ailerons on Bader's Spitfire have set their teeth into a hard right roll, and Galland's Me-109 is already following him.

Even at its most realistic, Taylor's work is touched with romance. "The Straggler Returns" portrays a badly wounded British Lancaster bomber limping home to base from a raid on mainland Europe. The airplane has emerged from storm clouds, its outboard left engine overheating and smoking profusely. But a streak of sunlight gently illuminates the craft and warms the green fields of England below.

—George C. Larson

Museum Calendar

Except where noted, no tickets or reservations are required. Call Smithsonian Information at (202) 357-2700 for details.

Thursday evenings. "Fly by Night" program; free family activities throughout the Museum. Through August 25, 6–9 p.m.

Summer Concert Series. Free concerts by U.S. military ensembles. Selected weekdays on the west terrace, noon to 1 p.m. **Country Current**—Navy country/bluegrass, August 4 and 11; September 1. **Fair Winds**—Navy vocal ensemble, August 5 and 25. **Commodores**—Navy jazz, August 12, 19, and 26; September 2. **Airmen of Note**—Air Force jazz, August 24. **Spectrum**—Air Force rock, August 31.

Photography Contest "Focus on Flight" is open to amateur photographers of all ages through August 31. Cash and other prizes awarded. Call (202) 357-2700 for entry brochure.

August 6 Monthly Sky Lecture: "The Refractory Revolutionary." The scientific contributions and turbulent life of Galileo. Thomas H. Callen, NASM. Einstein Planetarium, 9:30 a.m.

Late August A new exhibit highlighting scientific missions by the European Space Agency opens in the Museum's west end.

September 3 Monthly Sky Lecture: "The Lick Observatory." Shiloh Unruth, Lick Observatory. Einstein Planetarium, 9:30 a.m.

September 11–17 National Hispanic Week. The Museum's celebration includes free recorded tours in Spanish and Portugese and free lectures.

September 22 General Electric Aviation Lecture: "The Orient Express." Robert Barthelemy, National Aerospace Plane project head. Langley Theater, 7:30 p.m.

September 23 & 24 "Exploring Mars" events. Commemorating Mars' approach to Earth, the closest until the next century. Science fiction films, Langley Theater, September 23, 7:30 p.m.; symposium, Einstein Planetarium, September 24, 9 a.m.

Why I Don't Fly

I don't fly. I used to but I don't anymore. In the late 1960s airplanes took me around the world—a feat once noteworthy and the idea of which still gives me a thrill. But there came a day when I deplaned from an uneventful hop and knew I'd probably never leave the ground again.

I'm not going to take any cheap shots in an era of near collisions, pilot error, overbooking, and 15-hour delays. The airlines are just going through a bad spell of under-regulation. A couple more crises and no doubt things will return to normal.

It's not the disasters that have caused me to swear off flying. By staying out of the sky, I keep sweet the memories of past flights. One of the virtues of abstinence is that I can clearly recall every flight I've taken, and I want to preserve the idea of flying as a singular alternative chosen only in special circumstances. I quit flying when it became measurably less romantic than traveling by bus.

Air travel in the '80s measures up to my recollections about as well as a vehicular tour of Kilimanjaro compares to climbing it. A flight today is characterized by canned music, bored and irritated passengers, and seats far removed from a window. They even show films, for pity's sake, in an attempt to distract the passengers from the misery of being aboard an airliner. When they began to run box-office flops at 30,000 feet I knew it was time to become an Amtrak customer.

I'm not one of those people who live in the past. I have a computer, a VCR, and a microwave oven. But I have reached the age at which I'm entitled to say, "It was different in the old days." My first major flight was a transatlantic crossing on a Lockheed Constellation in 1958. Taking something like 14 hours, a trip like that was a true adventure. There was an aura of romance in toiling over the ocean through the long night. My seat back was broken, so I was forced to either recline completely or sit pitched forward hugging my knees. It was a Sabena flight, and a strapping Belgian stewardess lurched up and down the aisle wielding pots of coffee. I cringed each time she approached, and sure enough, during a bout of turbulence I ended up getting a scalding cupful sloshed down the back of my neck.

Aboard an Air France flight on a mid-winter trip to Poland with my father a few years later, I encountered the rudest people and the worst food in a lifetime of rude people and bad food. At Orly, the weekly Polish airline flight to Warsaw was already taxiing for takeoff. I bulled my way past the guard, ran out onto the tarmac, and waved it down. The Poles sent our luggage to Moscow, where it hibernated for a week while we suffered through record frosts without our long johns.

We took such setbacks in stride—discomforts can enrich an experience. When I got off the airplane—rumpled, stiff, scalded, or insulted—I was in *Europe!* I knew I'd *gotten* somewhere.

Some of my best flying moments took place on the first leg of a trip home from Africa. I waited at the airport—at the windsock, actually—in Tanzania, along with some African friends. A knot of people gazed patiently in the direction of the anticipated airplane, like a crowd on a subway platform. Not much more than an hour after its scheduled arrival time, a tiny dot appeared over the mountains. People pointed and spoke in hushed voices. There was none of the nervous and impatient chatter we hear in terminals today. The fact that people were beginning or ending momentous journeys was eclipsed by the vision of the magical machine, the distant buzzing of its engines the only sound in the still afternoon.

When it landed, a good many minutes after it appeared on the horizon, there were sighs and expressions of wonder and amazement for the beautiful DC-3. You just don't get this at Newark International.

I shook hands with my friends and took my place by a window on the side with seats (the other side was for cargo and livestock). There was no air conditioning, no pressurization, no music. There were enough holes in the cabin to provide plenty of fresh air, and throughout the flight I inhaled the unique fragrance of East Africa. I doubt we ever got much above a thousand feet. Below, a herd of giraffes ran over the grassland behind the airplane's shadow.

There were also giraffes to welcome us when we landed at Nairobi near dusk. At Embakasi Airport, I had a plate of curry and a bottle of beer in a dining room next to a walled garden. I'd been in and out of that airport for two years and had never noticed that it harbored a place of such charm.

As I ate my last dinner in Africa, I savored every moment of an experience rapidly drawing to a close. I was leaving a world where a harsh and haunting reality prevailed, and returning to an amalgam of the tame and synthetic. With the dust of the trail still on my boots, I boarded a Lufthansa flight to Europe, where I would make my connection for home. Thank God they didn't show a movie.

—Daniel Pinkwater

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Send Down the Clowns

You know those stories where a 95-year-old retiree makes his first parachute jump and it's so memorable and exciting he goes on to make weekly exhibition jumps for fun and profit? This is not one of those stories.

Years ago, a group of us military fliers were discussing bailing out of a disabled aircraft. I volunteered that I would not hesitate to depart a stricken airplane if the occasion arose. But in the back of my mind I had my doubts.

In the middle of the conversation I impulsively picked up the phone directory and found the number of a local airport where I knew parachute jumping was practiced. (In the 1950s the term "skydiving" was not yet in general use.)

I dialed the number and informed the man who answered that I wanted to make a parachute jump. He had three questions. Had I ever had any jump training? I replied that I had, in the Army, but only ground training. How much did I weigh? Two sixty-five, I told him. He said I'd need a 31-foot canopy—a modified cargo parachute. And when did I want to jump? This weekend, I replied. I was told to bring $25 and my hard hat, boots, and flight suit to the airport at 7 a.m. Sunday. It was that easy.

Sunday morning I arrived with my friends, changed into my flight gear, and reported to a little office surrounded by people suiting up. The jump coach told me my cargo parachute had not yet arrived but collected the $25 anyway.

People started packing their parachutes. They tied the tops of the canopies to their car bumpers and stretched them out in the dirt. Kids were walking on the chutes and I noticed a dog peeing on one. As the jumpers folded and wrapped, pebbles and debris got caught up in the packing. This casual approach surprised me—I had always thought this sort of thing was done under laboratory conditions.

The coach was lecturing one neophyte, who was all suited and chuted up. His jump was to be a static-line affair: one end of a strap would be attached to the aircraft with the other end going into his chute pack. When he jumped, the line would automatically pull the chute open. The coach told him that after he jumped and within the count of three, he should feel the shroud lines of the deploying parachute tickling his shoulder blades. If he didn't, he was to pull the D-ring on his emergency chute.

As the coach escorted the jumper to the door of the aircraft he repeated that after the count of three, if he had not felt the shroud lines tickling his shoulder blades, he had to deploy the emergency chute. The jumper looked irritated, but nodded.

As boarding began, the coach again began the routine about the shroud lines and shoulder blades. The new jumper turned around and shouted into the coach's face, "Do you have any confidence in this parachute? Because if you don't, let's take it off and I'll jump with the emergency chute." The coach smiled wanly and patted the student on the back. That is, on the back of the main chute pack. This, unhappily, resulted in the chute deploying all over the ground.

I was becoming unnerved.

Above us an airplane with jumpers aboard was checking the winds. A piece of red cloth floated down from the airplane and landed nowhere near the drop zone. After several more passes and pieces of cloth, one floated dead center into the zone.

On the next pass a jumper emerged. His chute blossomed but something was wrong: the canopy looked like a bow tie. The shroud lines had arranged themselves over the top of the canopy and the jumper was frantically trying to free them. The spectators murmured in concern. Without knowing what I was talking about, I shouted, "That guy's a goner!" The woman just in front of me turned and wailed, "That guy's my *husband!*"

The husband's attention was concentrated on things above him and he never saw the ground coming up. The medics carted him away with two broken heels.

The next man they dropped was caught by the wind and sailed by like he was headed for the next county. We were unable to see him land. To reach him we ran over a lot of rough terrain and finally resorted to running along a railroad track. A figure approaching on the track from the other direction turned out to be the wayward jumper carrying his deployed chute. On his landing he had narrowly avoided a railroad trestle and a patch of prickly pear cactus growing around it in abundance.

They started dropping those little pieces of cloth from the airplane again.

Near the drop zone was a barn, emblazoned with the advertisement "Chew Mail Pouch Tobacco." Next to it was an old single-story house with a small porch and a cow grazing out in front. The next jumper was headed straight for the house, and we watched open-mouthed as he went right through the roof.

We later learned that the old farmer who lived there had been watching TV when this apparition crashed into his living room. A moment later the jumper burst out the front door followed by the farmer, who was swinging at him with his cane, and the farmer's dog, which was snapping at the jumper's legs. He didn't get very far—his canopy was still draped around the hole in the roof. His harness jerked him to a halt and he fell. Every time he got up to run he was jerked down again. The cow kicked up its hind legs in alarm at the commotion.

About this time I found out that the 31-foot canopy would not be forthcoming that day. My friends waited for me to say, "Fine, we'll do it another time." Instead, I

Illustrations by William L. Brown

surprised both them and myself: "What type chutes do you have for me?" I asked. "Only a 24-foot-canopy military parachute," I was told. "I'll use it," I said, knowing it was too small for someone my size. My buddies looked at me with new-found respect. "Hell, I'd jump with a lace doily rather than disappoint my friends," I added.

The jump crew chuted me up and took me to the Piper Tripacer from which I would jump. Both the rear door and seat had been removed. I was to sit on the floor, the coach explained, with no safety belt, and hang on with my legs dangling out the door. At the proper time I was to get out and stand on the landing gear while holding on to the wing strut. I practiced this move and found there was no way to lean out and get positioned while keeping at least part of me in the airplane. I would have to lunge at the tire and strut with no way to catch myself should I change my mind. I was not enthusiastic about this arrangement.

A bystander, who turned out to be a 100-jump veteran, had a few words of advice. "Your chute is far too small," he said. "You're going to hit pretty hard." As he walked away he added, "That's really a racing chute you're wearing."

"What do you mean, a racing chute?"

"It means I guarantee you'll beat everyone to the ground."

We took off, and I sat with my legs hanging out. Seeing the ground recede with my feet in the foreground gave me a case of height fright I'd never experienced in some 15 years of flying.

At 1,500 feet the jumpmaster indicated it was time to get out. I lunged for the tire and strut and was stopped short just before the seat of my pants left the edge of the floor. My parachute pack had caught on something. The jumpmaster worked it free and again I lunged, hoping the pilot had remembered to set the brake so the tire wouldn't turn.

I managed to get hold of the strut with one hand and get one foot barely on the tire. I then got my other hand on the strut and got my dangling left leg to join the right on the tire. I was so pleased with myself that I smiled at the jumpmaster, who took my picture just as the airstream inflated my cheeks. I looked like an idiot.

Finally, I was given the signal to jump. I did so with no hesitation, and began falling like a sack of potatoes. I felt the shroud lines tickling my shoulder blades, as advertised. Suddenly I was jerked short. Pebbles pelted my hard hat. As I drifted down I could easily hear people talking and dogs barking below—the canopy formed a parabolic dish that collected and amplified all the sounds from the ground.

I had mentally rehearsed my descent but things were already getting out of hand. I was oscillating in a huge arc under the canopy. I attempted to right this by pulling on the risers opposite the swing, but that only made things worse.

I looked down. One hundred feet, I judged. I was about to flex my knees and pull on the risers for touchdown when I was driven into the ground like a tent stake.

When I came to I was being dragged by my parachute. My mouth seemed to be full of fine gravel, which turned out to be tooth enamel. Suddenly I realized there was a kid walking alongside me drinking a can of soda. He didn't ask if I needed help. He just walked along slurping the soda and watching me being abraded to death. I crawled downwind of the chute, wrestled it into a manageable armful, and struggled to my feet.

I never jumped again. Every time I get within 20 miles of that airport my back hurts. I heard that after my landing they named the drop zone the Impact Area. If I ever have to leave an airplane in distress I'll leave the parachute in it. I don't think I'll hit the ground any harder than I did with that racing chute.

—O.H. Billmann

Reef Encounter

Air Whitsunday takes its passengers on, above, and below the water.

John Everingham

by Terry Gwynn-Jones

Australian fliers say it's no good applying for a job with Air Whitsunday unless you have webbed feet and can handle a submarine. Australian fliers have been known to exaggerate.

Still, the pilots who fly for the southern hemisphere's largest seaplane operation do more than command aircraft. Their job includes snorkeling, scuba diving, tour guiding, and boat handling—the combined talents of a cruise ship staff.

Sixteen years ago only one man met all the requirements: Kevin Bowe. But despite his qualifications, Bowe didn't get much encouragement when he launched Air Whitsunday in 1972 with a three-passenger Lake Buccaneer amphibian. He smiles as he recalls the advice one aviation expert gave him: "You'll never make a living from seaplanes. It's a mug's game. Everyone who's tried has gone broke."

Australia's best known seaplane pilot is entitled to the last laugh. Today, with his wife Sue and 10 to 15 pilots—the number varies seasonally—he operates a 12-plane fleet that commands the skies over Australia's Great Barrier Reef.

The airline's primary destination is an idyllic lagoon 50 miles off the mainland in Hardy Reef, a part of the coral lacework that stretches 1,200 miles along Australia's eastern seaboard. While pilots flying tourists in search of Crocodile Dundee's Outback have to contend with kangaroos and cattle on their bush strips, Air Whitsunday's seaplaners keep their eyes open for basking turtles, cavorting dolphins, and "bommies"—Aussie for coral outcroppings—during their watery landings.

The Bowes live in a log-cabin-style house on their own airport, a small grass strip carved out of the rainforest on the Queensland coast, a thousand miles north of Sydney. Takeoffs and landings are real bush pilot stuff, with departure and arrival routes that force the fliers to weave through the surrounding hills. Nearby lies Air Whitsunday's main base terminal and the maintenance hangar the Bowes built after purchasing the airstrip in 1982. A Grumman Mallard, a Partenavia P.68, two Britten-Norman Islanders, three de Havilland Beavers, and three Lake Buccaneers—all amphibious—are based at the airstrip. A mile off its southern end, two Beaver floatplanes operate from the sheltered waters of Shute Harbour.

Today's multimillion-dollar operation is a far cry from the hand-to-mouth early years, when the Bowes had to sell their cars to raise the $3,000 deposit for their first Buccaneer. They

Terry Gwynn-Jones

When Kevin Bowe started his seaplane service in 1972, skeptics predicted failure; today he's sitting pretty.

Tropic Bird *surveys the sandy beaches and clear waters that attract tourists to the Great Barrier Reef.*

set up business on the beach of Happy Bay, a small resort island, and named their one-plane airline after the nearby Whitsunday Passage. In those days it was strictly a two-person organization. Sue promoted business, sold tickets, manned the base radio, and managed the office. Kevin flew tourists out to Hardy Reef to reefwalk and snorkel on the edge of Australia's continental shelf.

Kevin soon became the area's aerial watchdog, locating missing yachts, picking up injured fishermen, delivering urgently needed spare parts, and reporting on sea conditions. He and his little seaplane became local celebrities. His appreciation of the delicate reef ecology made headlines when he started the world's first aerial garbage service, flying the trash of a schooner permanently moored at the reef back to the mainland rather than see it tossed overboard. All the while, he kept an eye out for poachers furtively pillaging the reef for giant clams.

He discovered that seaplanes need protection, too: inadequate anti-corrosion measures or just plain laziness had been the downfall of many would-be seaplane entrepreneurs. Determined that his Buccaneer would not become another rust bucket wallowing in the warm saltwater tropics, Bowe taxied it back onto dry land every evening, washed it down completely with fresh water, and treated all the hinges, linkages, and unpainted metal with anti-corrosion fluid. Although a tedious procedure, it has become part of the everyday routine of all Air Whitsunday pilots.

Meanwhile, the Bowes worked on their business plan. "We realized that the key to our survival was to give passengers more than just another joy flight," Kevin says. "We decided to provide a total reef experience. From above, walking on it, and beneath the water. To do this the pilots had to be multi-talented reef experts."

They found the right formula. By 1981 the Bowes operated five Buccaneers, employed 10 pilots, and had carried 100,000 tourists to the reef. Kevin ended up spending most of his flying time in the check-and-training role, made all the more critical—and complicated—by reef conditions. "The sea is extremely demanding," he explains. "Even in the sheltered areas of the reef we encounter rolling swells and sometimes have to contend with three- or four-foot chop . . . . In seaplaning you learn very quickly that with tide, current, sea state, and wind constantly varying, every landing is different."

Air Whitsunday training captain Rodney

John Everingham

Johnston elaborates: "Water handling is the most important factor in seaplane operations," he says. "Some pilots take to it easily, others never make the grade. We begin by spending hours practicing taxiing on and off the step, into wind, downwind, and crosswind. All require specific techniques to prevent digging in a float and to minimize spray hitting and wearing away the propellers. We even have to teach our pilots how to sail their aircraft. It's a technique that we sometimes use on very windy days operating in narrow, coral-bound takeoff paths. In those conditions the wind's weathercocking effect can make it impossible to turn the aircraft after landing." To return to the takeoff point in such cases, they sail backwards, letting the wind push the airplane and using the rudders, ailerons, flaps, and little bursts of power for directional control.

Ironically, the most difficult condition for landing can be calm, glassy water. With no waves or objects on the surface by which to judge height, it is virtually impossible for pilots to know when to flare for landing. For such conditions, Johnston says, "we teach our pilots to peg a stable power-on approach speed, set up a descent rate of 150 feet per minute, and literally fly the aircraft down an imaginary glide slope, throttling back only when they contact the water. It takes a bit of nerve the first time, but we find it works like magic."

Air Whitsunday pilots are expected to master a number of specialties, including the Reef's diverse ecology (below and right).

John Everingham

The basic water endorsement for new Air Whitsunday pilots takes at least 20 hours of dual instruction. No pilot is allowed out to the reef alone until he has completed a minimum of 250 water landings and has made at least 10 reef flights under the checker's watchful eye.

In 1982, with the numbers of pilots and passengers on the rise, the Bowes decided they needed more airplanes. They took a deep breath and borrowed a million dollars—"It didn't sound much when we said it very

Terry Gwynn-Jones

quickly," Kevin says—and purchased two vintage 1940s 14-passenger Grumman Mallards. In flight the Mallards, christened *Frigate Bird* and *Tropic Bird* in honor of two Pacific seabirds, attracted envious on-radio quips from passing airline captains. Silver-haired old seaplaners high on nostalgia turned up "to hear just once more the sound of water rippling beneath the hull," as one of the seaplane buffs put it.

Australia's media fell in love with the stately old ladies: within months of their arrival the pair became the most photographed aircraft in Australia. They sparked a revival of Australia's love affair with seaplanes, which began in the 1930s, when Qantas Airlines operated Short C Class 23 Empire flying boats to England, shrinking the Empire as winged-collared stewards cosseted passengers with morning tea and silver-service meals.

The Bowes have since sold *Frigate Bird* to a west Australian oil exploration outfit, but *Tropic Bird* remains popular with Air Whitsunday passengers. On a recent flight out to Hardy Reef, captain Ian Johnston (Rodney's brother) told his passengers that for two decades *Tropic Bird* had been the aerial news and camera platform of the *New York Daily News*. British tourist John Evans, on his first seaplane flight, seemed more fascinated with the aircraft than with the stunning reef 500 feet below. Leaning into the cockpit he asked why such aircraft are no longer built and what it would cost to make a modern *Tropic Bird*. "I couldn't hazard a guess how much it would cost to manufacture these aircraft today," Johnston yelled back over the engines' roar. "They were designed as VIP machines back in 1947 and only 59 were ever built. I am told that 41 are still flying today. Such strength and dependability doesn't come cheap."

Approaching to land, Johnston passed over

Once they reach the Reef, tourists discover that the flight was the easy part: ambling on the spiny structure is no cakewalk (above).

Tony Fontes

two Air Whitsunday Beavers moored at nearby Bait Reef. The lagoon mirrored puffs of cloud and the several large passenger catamarans creeping along the reef. The Beavers' passengers were viewing coral through the submerged portholes of one of the company's two 14-passenger sightseeing boats. *Tropic Bird*'s tourists planned a less sedate underwater tour of the reef's coral gardens using the flippers, goggles, snorkels, and scuba gear stowed in the cargo hold.

Kevin, filling in as copilot/boatman, called out the pre-landing checklist, and a flurry of hands positioned the cluster of World War II-style engine controls that sprout from the Mallard's cabin roof. "Gear UP for the water . . . mixture . . . pitch . . . flaps . . . harness." As the checks were called Johnston eased back the throttles and the big roaring radials quieted to a muted throb. Coral and basking turtles flashed beneath the hull. There was an almost imperceptible shudder when the flying boat's hull touched down. As *Tropic Bird* settled into the water, glittering spray fanned up outside the cabin windows and a burst of applause filled the cabin. "That's a ten and a half," an excited Texan yelled from the back row as Kevin clambered up through the nose hatch and deftly grabbed the mooring line with a boat hook.

Ten minutes and a 50-yard boat ride later, everyone was walking on the reef. The colors and variety of coral were staggering. So was the passengers' realization that they were 50 miles out to sea, walking in a foot of crystal water on the world's largest structure built by living beings. "The billions of coral polyps that are this reef are tiny creatures not unlike sea anemones, except that some varieties have limestone outer skeletons," Kevin told the group. Warming to his favorite subject, he explained how each generation builds on the skeletons of earlier corals. "Just think of them as the world's tiniest masons building the world's most massive wall," he said.

While less adventurous passengers waded and snorkeled in the lagoon and reef pools, others made their way a few hundred yards over to the outer edge, where the reef marks the continental shelf—an underwater drop of several hundred feet. They donned snorkels and flippers to follow Johnston over the edge. Moments later, coming up for air, one shouted, "You should see the fish down there!"

A Sydney couple, in their mid-50s and clearly nervous at the thought of swimming in such deep water, peered longingly over the edge at the snorkelers below. Encouraging them, Kevin recounted how he taught an 83-year-old British tourist who couldn't swim how to snorkel. A few minutes later Kevin was shepherding the Sydneysiders over the edge.

Air Whitsunday routes include touring flights between Shute Harbor and Hardy Reef and runs to several resorts.

On the return flight from the reef, passengers were given an aerial tour of the Whitsunday resort islands. Holiday-makers on the dozen resorts often opt to arrive and depart by Air Whitsunday's Buccaneer water taxis. The company also runs commuter services to the major coastal cities and Lindeman Island using the Britten-Norman Islanders and the Partenavia. There is another Air Whitsunday base 150 miles away—at Townsville—where, in addition to making reef flights, the pilots will soon be taking tourists to the world's first floating hotel. (Besides a floating tennis court and swimming pool, the Four Seasons Hotel—moored 45 miles off the coast, at John Brewer Reef—will feature an underwater marine observatory.)

Kevin and Sue's dream has come a long way from the beach at Happy Bay, but there is still one last service they are determined to provide as soon as they can find the right aircraft. "We want to start a week-long barrier reef safari, cruising its length by day and overnighting at the resorts," Kevin says. "In a way we will be turning back the clock to the era of those splendid old Empire flying boats. Just imagine aerial-touring the reef by day, lunching in lagoons, swimming off sand spits, or casting a lazy line from a coral cay."

His infectious enthusiasm is undoubtedly part of the reason he has been able to build Air Whitsunday and prove the skeptics wrong. "Until recently the Great Barrier Reef was one of the world's best kept secrets," says Air Whitsunday's operator. "That's all changing now and I believe our seaplanes have played their part."

Mallard takeoffs and landings are invariably splashy; training ensures that they are safe.

John Everingham

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PIAGGIO

In Italy, they build cars that look distinctive and go fast. Why should it be any different for airplanes?

by Stephan Wilkinson

Photographs by Lee Battaglia

The streets of Genoa make San Francisco seem as level as Iowa City. Looking from one block to see where the next might lead, you peer down onto the roof of a six-story apartment building. Genoans take elevators from one street to another. Microscopic Fiats negotiate switchbacks dizzy with precipitous possibilities. Six-foot-wide alleys squeezed between tall, crumbling old buildings lead steeply down into darkness.

This ancient harbor city, trapped between sea and foothills, is an odd home port for an airplane. You'd believe a new-design funicular, perhaps. Maybe a high-tech cog railway. But an *airplane?* Nah. The only airport for miles around is a runway reclaimed from the Mediterranean, a seawall strip that invariably gives passengers on final approach the feeling that they're about to experience Boeing as boat.

In fact, the main plant that builds the core of the remarkable new Piaggio P.180 Avanti entirely ignores the natural synergy between factory and runway: it has no airport at all. Avanti fuselages and wings are trucked to Genoa from the town of Finale Ligure, 30-odd miles up the coast, only then to be assembled into airplanes.

Yet seaport Genoa's Piaggio P.180 is as precedential an airplane as anything with civilian wings—"the most advanced nonfiction airplane project in the world," as one Piaggio official put it. The P.180 is a twin-engine executive turboprop that will compete directly against the anxiously awaited Starship, Beech's tail-less, all-composite, new-generation businessplane. The Burt Rutan-designed Starship has finally received its Federal Aviation Administration airworthiness certificate, but the effort was complicated by problems with its composite structure and its tail-first canard configuration. Piaggio, following a more conservative course, has built its Avanti largely of traditional aluminum. And though the Avanti has a canard on its nose—Piaggio engineers call it a "forward wing"—it also has a conventional tail.

The P.180 comes from a nation that has virtually no tradition of business airplane manufacture. It comes from a company that in 73 years of aircraft production has made . . . oh, 1,500 airplanes. (When the U.S. general aviation manufacturers were in their glory years, they produced 1,500 airplanes a *month.*) But Piaggio knows what it's up against. "I remember when I was in the States in '79," muses one of the Avanti's experimental test pilots, Giuliano Currado, "a surgeon at Lackland Air Force Base, where I was training, asked me did we have refrigerators in Italy. For sure there is that little step of comprehension that must be overcome by us before we can sell Avantis in America." Says Alessandro

The Avanti, Piaggio's sad-eyed speedster, easily tops 400 mph. The odd little wing on its nose helps.

Piaggio

An extension of Piaggio's tradition of "pusher" twins, the P.180 may hold the key to the firm's future.

Mazzoni, the company's chief engineer, "We would like to see great success for the Starship. It would make the new technology, the new shape [of the Avanti] that much more acceptable if it also comes from Beech rather than just from one of those barbarous people who live somewhere outside the U. S."

The Piaggio Company's Genoa headquarters is a nameless, unmarked building on a narrow street amid waterfront gantries and cranes. There is no corporate logo arching over the solid metal gate, no "Quality Is Job One" billboard on the lawn. There *is* no lawn. The gate, apparently keyed by a security guard behind tinted windows, grudgingly opens just enough to admit a car. The building is somber, secretive—a Genoese don in dark glasses.

Only when you reach the conference room upstairs do you get a hint of where you are. On the walls are framed blueprints, some of them taped and tattered. Double-slotted flaps, sophisticated leading edge slats, hydrofoil skis on a seaplane . . . but these are ancient drawings, dated in the early 1920s, 1930, '35—concepts well before their time. Who *are* these Piaggio people?

Shipbuilders, originally. Part of Genoa's merchant tradition. Columbus was born here, and he looked to the sea just as generations of Genoese had and would, perhaps because the only prospect inland was those harsh hills.

The original Rinaldo Piaggio (whose grandson, also Rinaldo, runs the company today) got into the business in 1884, building some small vessels but eventually specializing in opulent interiors for Atlantic liners. The steam locomotive and railway car trade soon caught his eye as well. By 1915 Rinaldo had come to realize that airplanes were pretty hot, too.

Piaggio's forte became seaplanes, naturally, and in 1923 he set out to capture the Schneider Trophy with a design by his resident genius, Giovanni Pegna. The cup, awarded to the winner of a timed competition among the world's fastest seaplanes, was so hotly contested that British and Italian Schneider racers frequently set absolute speed records despite the drag of their fat pontoons (see "The Schneider Trophy," June/July 1988). By 1929, Pegna's PC-7 was doing without floats at all, instead using small hydro-skis. A motorboat propeller under the tail would boost the racer onto the skis, at which point the busy pilot was expected

to transfer the 900-horsepower Isotta-Fraschini engine's power to the air propeller, lift off, and fly away to victory.

A photograph shows the airplane in a cloud of spray, lunging up onto its hydro-skis during a takeoff run that ended up going nowhere: every time the pilot tried to transfer power, the airplane coasted back onto its belly before the switchover could be completed. Oil on the transfer case clutch made it slip, explains a Piaggio engineer. Should have had two engines—one for the water, one for the air—another theorizes.

There have been no such problems for the Avanti—a more logical but no less imaginative design. In a sense, the Avanti's target is not a trophy but a television character: J.R. Ewing.

Chief engineer Alessandro Mazzoni is a bulky, sleepy-eyed man with tousled hair who perpetually looks as though he stayed up too late graphing a lift curve. With a Genoese accent but in excellent English (he spent several years in the 1960s working in Florida as an engineer for Piper Aircraft) he explains, "This aircraft was designed for a very rich man [it will sell for $3.7 million], and at the time we were designing it, *Dallas* was the prototype. J.R. Ewing was our model customer. We are trying to design a U.S. aircraft in Italy, not sell an Italian airplane in America. What kind of airplane would J.R. Ewing buy? It's a joke between us, but that is why the Avanti was designed with a very specific mission in mind—New York to Dallas or Dallas to Los Angeles. If the boss asks me how this airplane flies from Rome to London, we don't know."

The Avanti enters an arena that has already chewed up a number of contenders. The contest is to create a light, spacious, jet-fast yet fuel-efficient turboprop businessplane of advanced design. Bill Lear tried with the Learfan, a twin-engine/single-propeller, all-composite pusher—now defunct. The Avtek 400A and OMAC Laser 300, both canard pushers from small companies, have been crawling toward FAA certification. Piper has mounted enormous turboprop engines on its relatively elderly conventional Cheyenne twin to create a high-altitude speedster but is finding it hard to sell the $2.7 million machine in a depressed market. And Beech will probably end up with an estimated $350 million invested in the development of its Starship.

Many people think the game is pointless. The new turboprop designs will all cost as much as a variety of new and used business jets and will only go as fast as the slowest jet. The turboprops will use substantially less fuel, but does J.R. figure his miles per gallon? What he does figure, say some, is that he ought to have a jet, not just "a li'l prop plane."

If the naysayers are wrong, Rutan's Starship will be the Avanti's main opponent. A look at the numbers suggests that the Italians may have pummeled the Wichita Wonder: the Avanti will fly 60 mph faster, take off 3,490 pounds lighter, provide a wider and taller (though slightly shorter) cabin, carry the same number of passengers, afford the same 41,000-foot altitude capability though with less range, and do it all on 30 percent less horsepower. And while Beech may have spent $350 million, Piaggio hopes to get FAA approval for less than $160 million.

Piaggio engineers Felix Lasagni (left) and Manfredo Chiarvetto had help from Boeing . . .

. . . but the company's 60-year-old wind tunnel has done the lion's share of "flight-testing."

Manfredo Chiarvetto is the head of Piaggio's aerodynamics department. He is a handsome, mustachioed man who prowls the old Finale Ligure plant trying to keep his pipe alight. In his suede flight jacket and Eurowide tweed trousers, one tends to cast him as "the Test Pilot," but the Avanti he flies cruises only in Piaggio's wind tunnel.

The Finale Ligure factory, built in 1906, is so close to the rocky sea that Mediterranean breezes become vicious gales in the venturi-like alleyways between the buildings. The factory is a long, open, airy concrete structure, high-vaulted, arched, and columned. One expects to see the 5:15 from Nice pull in, wreathed in steam.

The whuffling roar inside is Piaggio's wind tunnel, sucking air from the factory hall into two large grilled openings on the building's second level and replacing the air with noise. "Now we get complaints from the workers," Chiarvetto admits, "so we have to schedule our work more carefully."

The Piaggio wind tunnel is old enough that the huge electric motor driving the 16-blade hand-carved fan is set atop wooden engine mounts from a Savoia-Marchetti S-55X flying boat, a squadron of which flew from Italy to the United States in the summer of 1933. Yet the tunnel and the work it represents are big reasons why Piaggio has come to challenge Big Beech from out of . . . one hesitates to call Italy "nowhere," but it's a long way from Wichita, Seattle, Long Beach, and Burbank. Says Mazzoni, "This tunnel has worked, day in and day out, for 60 years. No interruption. Wars? No matter. There are no problems with scheduling; it is always free of charge, always available. Research, optimization of the model, this is very important to us."

Maritime and aeronautical traditions commingle in Genoa; over the years, Piaggio has been involved in both.

For a brief period, the company's best known product was a motor scooter like the one leading this gaggle.

Piaggio started the P.180 project as a "what if" study, then designed an airplane on a computer, verified its performance in wind tunnels both at Finale Ligure and in the States, and then built the two Avanti prototypes, the only ones flying. (The first production run—a dozen airplanes—is slowly taking shape now.)

The company also shrewdly had Boeing build a pair of large, sophisticated Avanti models and test them in Boeing's own transonic wind tunnel in Seattle. "Yes, there was a political reason for going to Boeing," Mazzoni laughs. "We could have gotten the same capability here in Europe, a lot closer to home. But this made it 'an American aircraft.' When a customer asks us a technical question about the Avanti, we can say, 'Go ask your Boeing.' " (The deal, though costing $3.5 million, also produced good word of mouth for the Avanti and its unique three-surface configuration from the many Boeing engineers who learned of the wind tunnel results. As one observer puts it, "When Boeing speaks, aerospace listens.")

The Italians feel they hold a considerable edge not only in technology and performance but in aesthetics and quality—the legend of Old World craftsmanship that has so successfully sold us everything from MGs to Guccis. After two years in the United States, Mazzoni returned to Italy with considerable contempt for America's manufacturing methodology. "When I was at Piper, Karl Bergey [a highly regarded Piper engineer] used to say to me, 'Alex, you can never *imagine* how badly a part can be made and still work,' " Mazzoni says. "But Karl, who I admire very much, knew the lower limit of 'good enough.' Today I see in the U.S. two or three generations of general aviation engineers who have been trained solely to save money, not to improve the product. They don't know the lower limit."

What might otherwise seem arrogance is mitigated by Mazzoni's rumpled charm and obvious commitment to the concept of excellence. "Europeans enjoy quality," he says. "When a European buys something, the first thing he does is open it up, take it apart to see how well it is made. The American attitude is 'good enough.' If it works, it's okay. The car is just a box to go this place or another. Your airplanes are similar."

Unfortunately, it's possible that for many an American, Italian workmanship is reckoned to be *not* good enough. Fiat, which to Americans had become an acronym for "Fix It Again, Tony," no longer sends cars to the United States. Nor does once-glorious Lancia, another failure on the U.S. market. "We're

building the Maserati of airplanes," Mazzoni says. Yet Maseratis are as rare as Packards on American highways—and not because they are exotic or especially expensive.

Three things about the Avanti capture the eye. One is its shape: aluminum cucumber rather than the tube-with-wings form that production-minded U.S. engineers have made the norm. (A can-like fuselage is easier to manufacture than one shaped like Charlie the Tuna.) Another is the small canard that makes the tuna at times look more like a catfish. And a third is that the propellers push rather than pull the airplane.

The airplane's sleek fuselage comes directly from computer and wind tunnel, the point being to keep airflow "attached" over as much of the fuselage as possible. Airflow tends to remain laminar—flowing in orderly, non-turbulent, parallel layers—as long as the airplane's shape conforms to the airflow's natural course rather than trying to force the air to obey. "The fuselage is designed not for ease of manufacturing," says Mazzoni. "On purpose we forgot this problem. We have been able to convince the production people to accept the optimal shape." It's that shape, apparently, that accounts for a large part of the Avanti's performance advantage over the Starship.

To the surprise of Beech—"For years they laughed and said it was expensive and inefficient," Mazzoni gloats—another part of the advantage seems to be the use of the forward wing/canard in combination with a conventional tail (see "Head-on Tails," p. 42). "Today they are starting to copy us. Beech has announced that the second generation of aircraft to follow the Starship will all have three-surface configuration," Mazzoni points out.

Though the forward wing is innovative enough for Piaggio to have patented the design, it (as well as the rest of the Avanti) sprang from a configuration that can be traced all the way back to the twin-engine P.136 amphibian, Piaggio's first post-war project. The P.136 was reworked into the plodding but rugged P.166, a landplane that's still in production after 31 years. The P.166 also marked Piaggio's first confrontation with Beech. Initial demand for the slow but spacious Italian workhorse was strong, but Piaggio couldn't build them fast enough to keep up with the market. When Beech introduced the stately Queen Air, it snatched away the small

The beachfront factory (with the arched roof) lies 30 miles from Genoa in Finale Ligure.

but stable market for large-cabin twins.

Both the P.136 and 166 had high or mid-fuselage wings set entirely behind unobstructed passenger cabins, twin engines, pusher props, and squat landing gear that retracted into the fuselage. So does the Avanti. "The people who set up the configuration of the P.180 are the same people who worked on the P.136 and 166," Mazzoni explains. "We liked everything about the P.166 except that the CG [center of gravity] was limited." Since the cabin was entirely ahead of the wing, passenger weight had to be counterbalanced entirely by downforce on the horizontal tail. The large fuselage area behind the wing, there solely to support the tail, was unusable for anything but baggage. "This was the only thing we didn't like," says Mazzoni. "So we say we must find a way to lengthen the fuselage, and the way we found was to put another wing at the front. The P.180 configuration was born to allow us to use a greater length of the P.166 fuselage. At the beginning, many engineers laughed. It was barely workable, they said. At the end, we found many benefits."

Most of the Avanti's structure is traditional aluminum, but the made-in-the-U.S.A. tail is composite.

Most Piaggio engineers are lifers. Aerodynamicist Manfredo Chiarvetto, for example, joined the company the week after he got his engineering degree, 22 years ago. So it's no surprise that the brains behind the P.180 belong to the novices of 1946. "The man who drew the landing gear on the P.180 is the same man who drew the landing gear for the P.136," says Mazzoni. He compares this with what he saw in Florida while working for Piper: "Many of the workers, the day before they were picking oranges or grapefruits."

During a stint at Piper, chief engineer Alessandro Mazzoni learned how U.S. airplanes are built and sold.

Before a single Avanti is bought by an American, Piaggio must find an outfit to sell, support, and service the airplane—things the company could never do from a distance. Four times before, Piaggio has formed such bonds with U.S. companies—twice successfully, twice painfully.

The first marriage was arranged by Bruno Mori, now Piaggio's director of international operations, and industrialist Francis Trecker, who in the 1950s imported disassembled P.136s and sold them in the States as Trecker Gulls. Mori recalls, his accent strong but his words precise, "Rinaldo's father, Armando, ask-ed me, 'Bruno, why you sell airplanes in America? It is like selling ice cream in Alaska.' I find that sell-

Head-on Tails

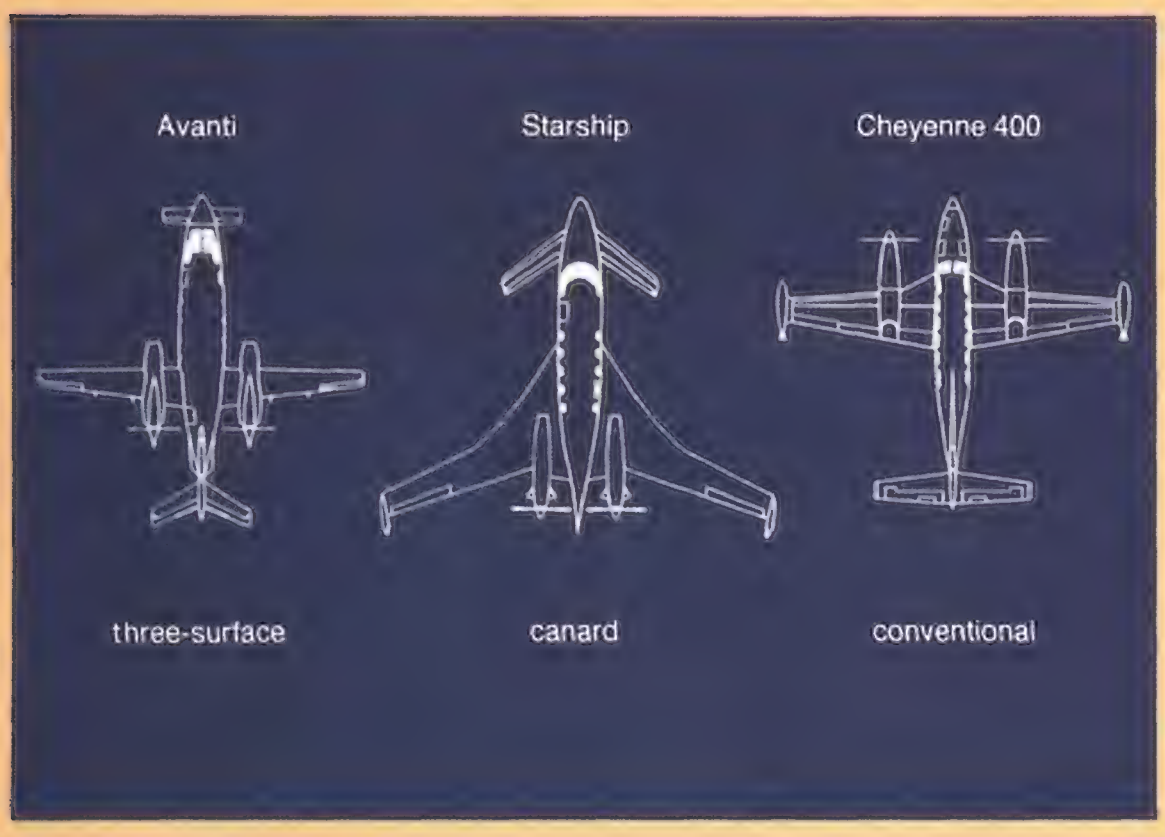
Every several decades, the aviation world rediscovers canards. The Wright brothers were the first to fly tail-first, of course, and Beech Starship designer Burt Rutan is the most recent. Canards seem to have an undeniable advantage: eliminate the conventional horizontal tail and its downforce at the rear and instead balance your airplane with lifting surfaces at the front. Typically, the conventional tail's download consumes about 10 percent of a wing's lift at cruise. The wing of a conventional airplane therefore has to work hard enough to support an airplane that flies as if it's 10 percent heavier than it actually is.

The canards' payoff isn't quite that easy to cash in, however. Canards themselves create a certain amount of drag because they must operate at a higher lift coefficient—closer to stall, in other words—than the main wing. It's absolutely vital that canards stall well before the wing does so that the airplane's nose can drop, thereby initiating a spontaneous stall recovery. Were the wing to stall while the canards continued to lift, the airplane would point its nose straight toward heaven and then take its pilot there—such a stall would be unrecoverable.

Even worse, assigning some of the horizontal tail's functions—controlling the airplane's pitch and trimming for varying loads and aerodynamic conditions—to the canards complicates things considerably. A conventional horizontal tail, which is usually set at a slightly negative angle of incidence, becomes *more* powerful as an airplane's nose pitches down whenever the flaps are extended. Canards actually lose effectiveness when the flaps are deployed. The Starship's canards must swivel forward from their swept-back cruise position in order to move their center of lift farther forward, increasing their moment arm to compensate for that strong nose-down pitch. They also have a variable-camber trailing edge to assist the main wing's elevons in commanding pitch up or down.

Though it has canards, the Avanti adds that widely celebrated third surface: a conventional horizontal tail. Piaggio's theory is that simple canards unload the tail enough to virtually eliminate the drag of its downforce, and this allows the wing to be made considerably smaller, lighter, and less draggy. However, maintaining enough of a conventional tail to take care of all the airplane's pitch control needs—especially the trim—means the canards can stay simple and effective, and the horizontal tail can be made small enough to greatly reduce drag. Piaggio feels that the Avanti, with its "three-surface configuration," takes advantage of the benefits of canards without succumbing to the troublesome novelty of going tail-less.

If, as rumor has it, the Starship ran into unexpected stall recovery complications (Beech recently changed the supplier of the instrument that indicates angle of attack) arising from the assignment of the bulk of its pitch-and-trimming tasks to its busy little canards, then Piaggio's decision to use three surfaces will seem very wise.



ing ice cream in Alaska is a good business." Trecker sold about 100 Gulls.

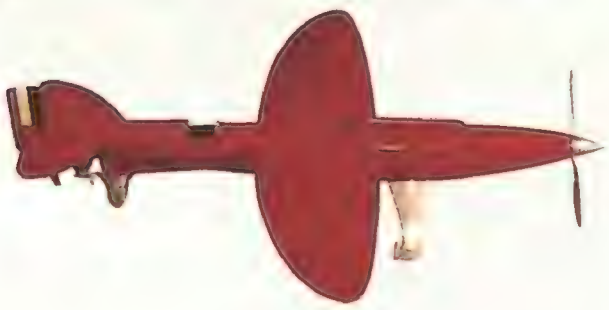
Sears, Roebuck turned out to be another amicable partner when the Piaggio Company found itself plundered and defeated after World War II.

"It was a real mess," recalls Mori, who joined the company in 1946. "There was no work at all for Piaggio. But luckily, there was a design ready by Rinaldo Piaggio's uncle Enrico: the Vespa." The Vespa, as many a sophomore knew well, was a bustle-bottomed powered wheel with a seat, a willfully unstable little scooter that whined like a wasp and wanted badly to lie down like a dog. But it was so compact, reliable, logical, and economical a package that it became, in a sense, Genoa's open-air Beetle. "That was our salvation," says Mori. The Vespa caught the attention of Sears, which gave it the Allstate blessing and sold tens of thousands in the United States.

Vespas have been made by the Piaggios to this day, but in 1964 the family split: "Piaggio and Company," controlled by Enrico's daughter and Fiat (she married an Agnelli), became the scooter builder, "Industrie Aeronautiche e Meccaniche Rinaldo Piaggio" the airplane maker. The companies are entirely independent.

By the time of the split, Piaggio had already cooked up a deal with Douglas Aircraft, whose European rep showed up full of enthusiastic plans to have Piaggio build a business jet Douglas had designed. (The airplane, which looked like the offspring of a Learjet and a Grumman Intruder, owed its bug-eyed appearance to a Navy requirement that its forward visibility be conducive to carrier landings. Ed Heinemann of A-4 Skyhawk fame drew up the first plans, but when the Navy hedged, Douglas put it on hold. Piaggio revived it as the PD-808—a joint venture with Douglas.) "It was a disaster," says Mazzoni, laughing. "We got a *terrible* buzz in the cockpit at Mach .55 [from a supersonic shock wave] and couldn't make it go any faster until we reshaped the whole cockpit area."

But while Piaggio was building PD-808s, Douglas became deeply mired in financial problems caused by overcommitment to the airliner market. The company was forced to sell control to



Tiers of models in a loft at Finale Ligure remind the current generation of engineers that ideas outnumber production airplanes (top)...

...but ideas have always been Piaggio's stock in trade. The PC-7, a 1930s racing seaplane that survives only in the form of this model, incorporated hydrofoil landing gear, a boat propeller near the tail to get it started, and a clutch to shift power to the air propeller. Its flaws were not corrected, and the PC-7 never flew.

McDonnell, and the new McDonnell Douglas terminated its involvement with Piaggio.

It happened again with Gates Learjet, Piaggio's original partner in the Avanti program. (The airplane was initially announced as "the Gates Learjet-Piaggio GP-180.") It seemed the perfect union: bizjet expertise, manufacturing facilities in the States, Gates dollars to help offset development costs—and most important, marketers who'd made Learjet a household word. Marketers who were on a first-initials basis with J.R. Ewing. In 1986, Gates Learjet, dragged down by the United States' deepest-ever general aviation depression, backed out of the Avanti project.

Some think the Avanti died that day—that any business aircraft manufacturer must sell at least 70 percent of its output in the United States to survive, and that Piaggio would never be able to do so now. Certainly that will prove true if Piaggio is unable to form an alliance with a U.S. partner... a partner such as Piaggio's old friend Boeing, perhaps. Might the world's biggest air transport manufacturer agree to sell the world's most advanced executive turboprop? Stranger things have happened: in 1963, Pan Am, on the advice of consultant Charles Lindbergh, imported a little-known French bizjet called the Dassault Mystère 20, renamed it the Fanjet Falcon, and established the forerunner of what has become one of the most admired lines of business aircraft in the United States.

And what about Sikorsky, which has already contracted to produce the 20 percent of each P.180 (mainly the tail and nacelles) that is manufactured of reinforced composites? One Piaggio spokesman denied that such a tie-in would be logical, saying, "Sikorsky knows nothing of the general aviation business." Yet Sikorsky, a division of the immense United Technologies group (its Pratt & Whitney Canada division makes the Avanti's engines), has for years been busy selling $3.2 million S-76 corporate helicopters to the very same market that Piaggio hopes to reach.

Perhaps the most logical possibility arises from the purchase this spring of 31 percent of Piaggio's stock by the

large Italian manufacturer Aeritalia. (The Piaggio family still owns 60 percent of the stock, making the company the oldest private one of its size in Europe, but that could change, especially if difficulties marketing the Avanti force Rinaldo Piaggio's financial hand.) Aeritalia is a manufacturer of military jets and cargo aircraft, but recently it acquired 40 percent of the Dee Howard Company in San Antonio, Texas.

Howard is a "completions center": it designs, manufactures, and installs interiors, avionics, and equipment for corporate jets, much as the first Rinaldo Piaggio did for oceanliners. Certainly Howard would be able to deal with a 10-seat turboprop. His specialty is fitting out 747s for potentates: a recent job for a Middle Easterner reportedly included a completely equipped operating room for the owner, who travels everywhere with a strapping young living organ do-

Rinaldo Piaggio (top) adheres to a family tradition of riding the crest of technology's wave. Now he's betting the family company that two Avanti prototypes (right) in flight test will earn their certificates later this year—and that J. R. will want one.

Piaggio

nor ready to volunteer his personal parts if needed.

Christopher Columbus bravely opening a new world provides a Genoese metaphor difficult to resist as Italy sets out to conquer America with the Avanti. Yet there was another famous homeboy—the brilliant Genoese statesman and naval leader Andrea Doria. It's no secret that his namesake ended up off the coast of Nantucket one summer day in 1956. It would be a shame if Piaggio's Avanti venture were to founder as well.

Perhaps Piaggio has miscalculated the market, which the company sees changing radically in a way it doesn't yet understand. "All the traditional manufacturers are disappearing, and the traditional customer is disappearing," says a slightly baffled Mazzoni. "There will be entirely new customers, new manufacturers. Everyone is saying the general aviation industry will recover, yet it remains bad. It will never recover in the same way. It will be different, but we don't know how. Who will play the major roles is a question."

There is a musty, wide-planked room, an upstairs space alongside the huge wooden barrel of the Finale Ligure wind tunnel, that serves as a storeroom of Piaggio's optimism. On the ceiling-high pipe racks and model stands are collected all the hundred-odd designs that the company has brought to the tunnel testing stage, including 51 that have actually flown. The room is a museum of the aeronautically weird and wonderful: a manta-winged 1926 Stealth Bomber lookalike impossibly ahead of its time . . . a four-turboprop, high-wing, short-takeoff-and-landing commuterliner designed two decades before de Havilland introduced its four-engine Dash Seven . . . a 1930s bomber with high-lift devices that would do a 727 proud ("It was a disaster," Chiarvetto groans. "The very high lift of the aircraft was not compensated by the tail") . . . a 1945 fighter with an air-cooled radial engine buried mid-fuselage, a huge mechanical stove thrashing around behind the pilot ("Very maneuverable, but it came too late," says Chiarvetto) . . . an elongated 1930s trimotor heavy-lifter with two tiny *Voyager*-like canopies—frog eyes for a pair of lonely pilots . . .

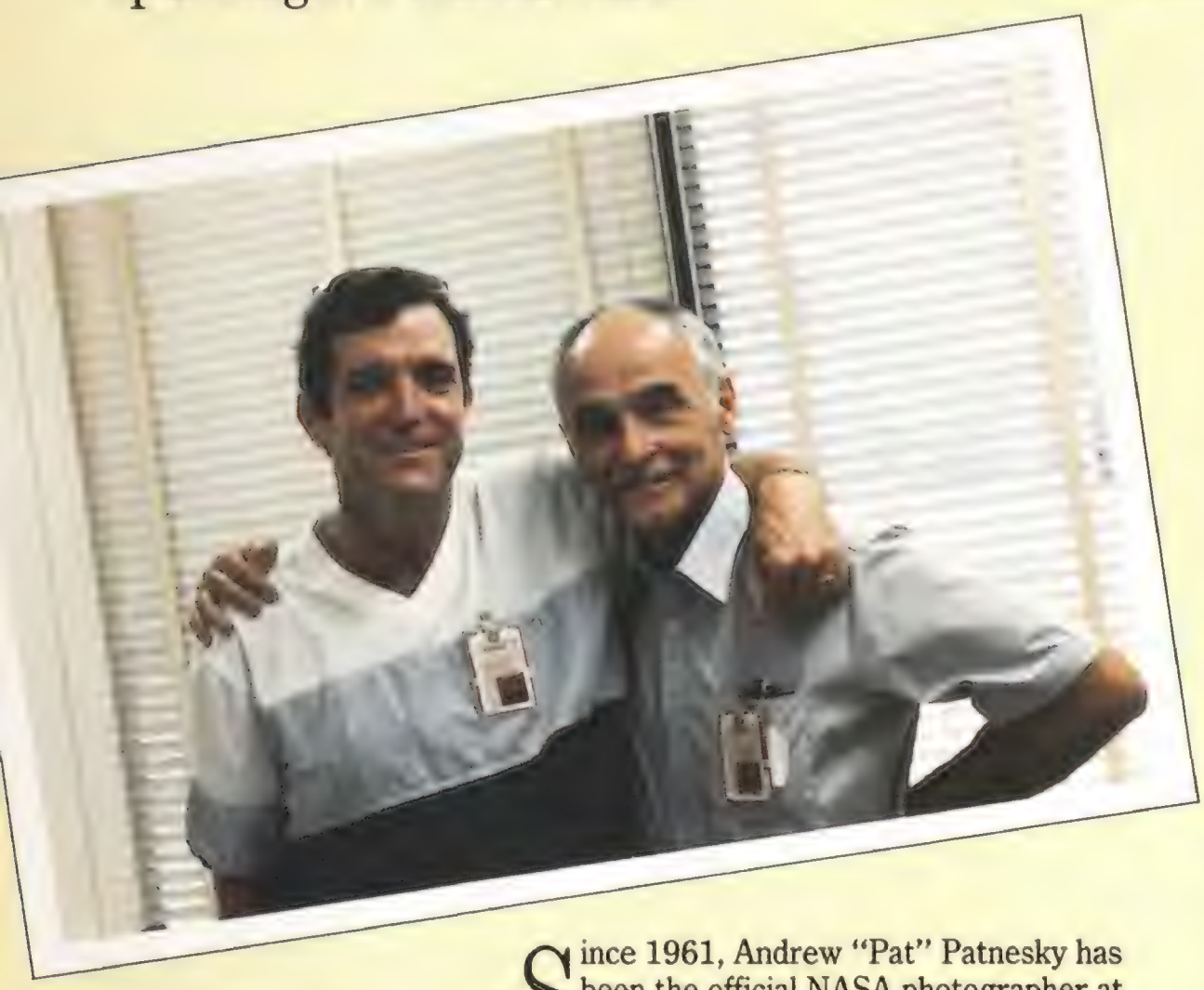
If the Avanti's destiny is to gather dust amid these models, it won't be the airplane's fault, for these optimistic Genoese have created a design that has already proven itself in flight. "The P.180 is now a reference point for all manufacturers," claims Mazzoni, "and that has never happened to us before." All that remains is for J.R. Ewing to pull out his checkbook.

Space Shots

by Alcestis R. Oberg

For over a quarter-century Pat Patnesky has photographed spaceflight's human face.

1962: Residents of the future Manned Spaceflight Center site.



"You are a great photographer and an all-around good guy," wrote Challenger *commander Dick Scobee (left, with Patnesky) on a copy of this photograph.*

Since 1961, Andrew "Pat" Patnesky has been the official NASA photographer at Houston's Lyndon B. Johnson Space Center. His pictures, a chronicle of the human side of spaceflight, have appeared in newspapers, magazines, and books thoughout the world. As an unintrusive witness to the events at the space center, Patnesky has been able to photograph the human stories behind-the-scenes. His photographs—all credited only to an impersonal "NASA"—capture a number of striking and emotion-filled images:

- the reverent face of a scientist peering into a glass case containing moon rocks;
- flag-waving rapture erupting in mission control the moment the space shuttle *Columbia* rolled to a stop after its first mission;
- eager faces pressing against the windows of a limousine waiting to carry Apollo astronauts home;
- dejected expressions of NASA officials forced to cancel a flight;
- intense horror on the face of a flight director who has just realized that the shuttle *Challenger* has been destroyed.

Patnesky's connection with NASA slightly predates the existence of the Johnson facility. In 1961, after a career as a photographer that had started in 1939 with the Army Air Corps, Patnesky became the Air Force's photo lab chief at nearby Ellington Air Force Base. Late that year he retired from the Air Force to join NASA. In January 1962 he was assigned to photograph the ranchland that had been proposed as the site for the new space center. He returned with a photo that still hangs in his office—a shot of the local bovine residents all gazing toward the camera.

Soon after Patnesky took the shot the cows were displaced by the rambling buildings of the Manned Spacecraft Center (it was renamed after President Lyndon Johnson in 1973), which has functioned as mission control for manned space programs from Gemini through the space shuttle. Here, manned spacecraft are designed and tested and astronauts receive their training.

Patnesky, now 68, has kept busy photographing all facets of the activities at the center for the past 27 years. Even before the facilities were finished he was photographing the Gemini 3 astronauts' triumphant return to recovery aboard an aircraft carrier, their

The original Mercury astronauts, looking suitably Texan.

NASA Wernher von Braun and MSC's Robert Gilruth.

NASA Walter Schirra and family meet with President Kennedy.

tumultuous welcome in Hawaii, joyful hometown parades, and a formal White House reception. He also covered the often arduous astronaut training, which included trips to the frozen wastes of Iceland and volcanic craters in Mexico to prepare for moonwalks, as well as survival drills in the jungles of Panama and the deserts of Washington state and Arizona.

Besides covering the astronauts and mission controllers, Patnesky's job also called for him to photograph the life outside the spotlight: new NASA equipment, award ceremonies, VIP visitors, ongoing experiments, and the activities of the hundreds of spaceworkers who labor, for the most part, behind the scenes.

In quieter times, Patnesky has recorded moments of natural splendor around him: deer racing between the modern space center buildings, a rare snowfall blanketing the semi-tropical Houston vegetation, a bright moon over mission control the night the Apollo 8 astronauts circled it—the first people to do so.

Patnesky credits much of his work to luck and his talent for attaining virtual invisibility. His favorite camera is an old Leica with a nearly silent shutter. He rarely uses flash or

NASA The rendezvous of Geminis 6 and 7 called for cigars.

tripods and detests automatic film advancers that "sound like machine guns." He says, "I never ask people to look up or pose and I just don't take pictures if they don't want them, or when they're looking pinched or grim. A photographer needs to know when and how to use long lenses, so as not to intrude on or interfere with the people. The face changes constantly, and if you try to set up a shot too long, the moment is gone. It's best if you take many pictures with many different lenses, so you can get both backgrounds and close-ups."

Patnesky's job has had its risks. While crawling over some rocks in Arizona to get a good picture of three astronauts in a crater, he fell face first down jagged volcanic rock. "Then there's the time I almost got shot by the Secret Service," Patnesky says, grinning. Prior to a 1981 visit by President Reagan to the Johnson Space Center, mission control personnel were warned about exciting the somewhat twitchy Secret Service agents with sudden moves or loud sounds. When the visitors arrived, Patnesky positioned himself precariously over a console in order to get a good shot of the president as he spoke to the shuttle astronauts in space. As he was taking his pictures, Patnesky lost his balance, fell off the console, and knocked over bookcases and a trashcan as he crashed to the floor. The Secret Service grabbed for their guns and Patnesky was sure he was going to die. When he opened his eyes, President Reagan and Johnson Space Center director Christopher Kraft were peering over the console at him.

His mistakes over the years have been few, and he's usually learned something from them. "A few times I didn't have the right lens with me when something came along," he recalls. "Or sometimes, when I was supposed to shoot a piece of new equipment, I expected them to have it standing out in the middle of the room

and it was stuck back in some dark corner—and my flash was in the office. But . . . you develop an instinct after a while for what you need."

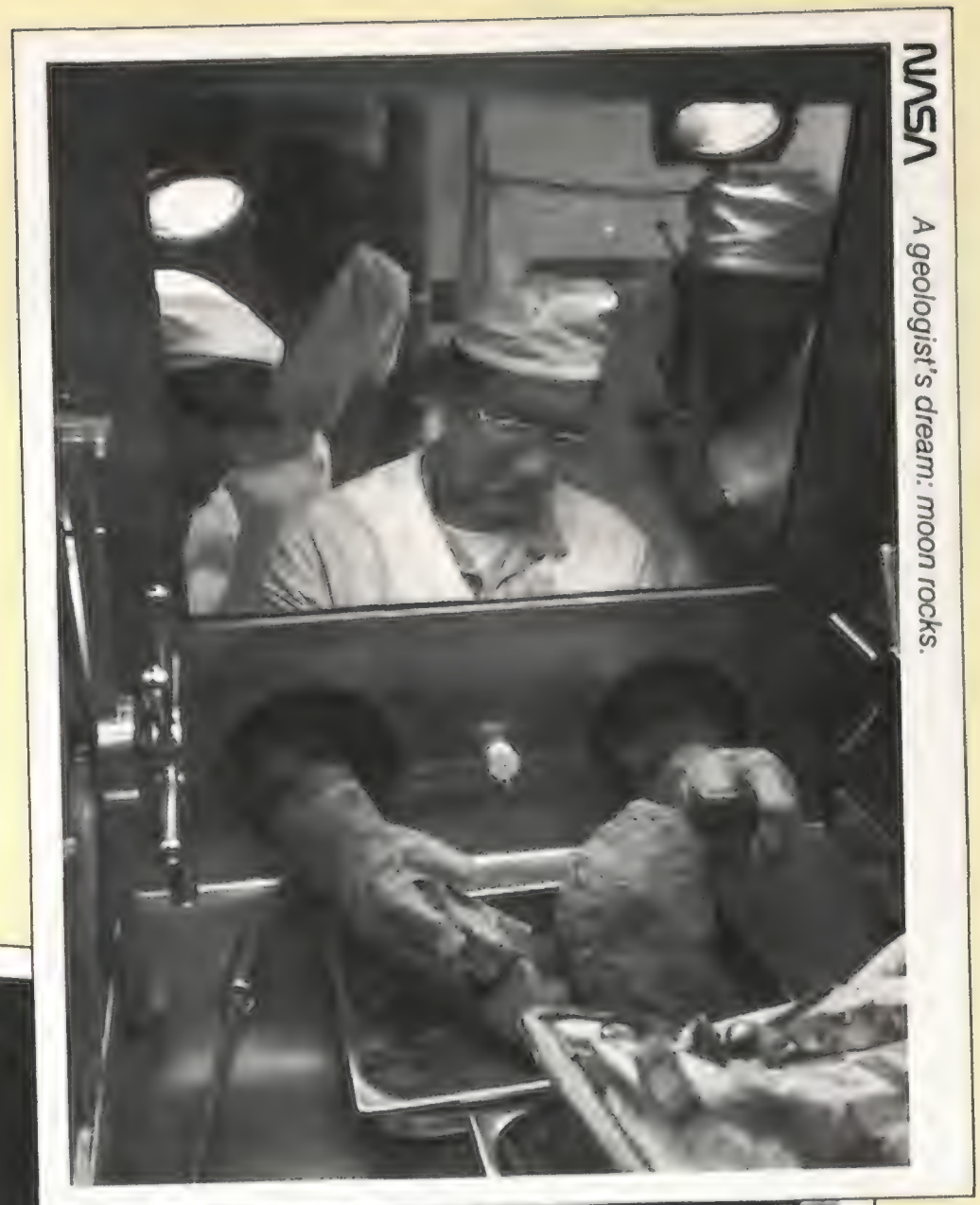
On launch days, Patnesky carries four cameras and eight lenses into mission control to cover a wide range of media demands: wide angle, close-up, color, black-and-white, prints, transparencies. Wire services like certain types of photos; glossy magazines and books require others.

"A good photographer has to compose a photo like an artist but has to be prepared for anything like a photojournalist," he says. "You have to have in mind what you want to shoot but be alert for what might happen."

Patnesky has had to suppress his reactions to events and keep his mind on the task at hand. During the first moon landing, he clicked away as mission control erupted in joy: "I was shooting so much, I didn't have time to jump up and down."

Patnesky, unlike news photographers, works on a regular basis with the people he photographs and feels perhaps more pressure to avoid crossing the fine line between doing his job and exploiting his subjects. He has to be acutely aware of the shifting trust between photojournalist and news subject. When the *Challenger* exploded, he took his pictures and then backed off. "Everybody became pretty still. They were stunned. I was, too," says Patnesky, who had been the last person in the Houston space "family" to shake hands with the *Challenger* crew just before they boarded the airplane to go to their launch. "I didn't take as many photos as usual. I guess I eased back, partly because the controllers weren't in the mood, partly because of my own feelings."

The camera, he admits, is not always adequate for capturing the emotion of the

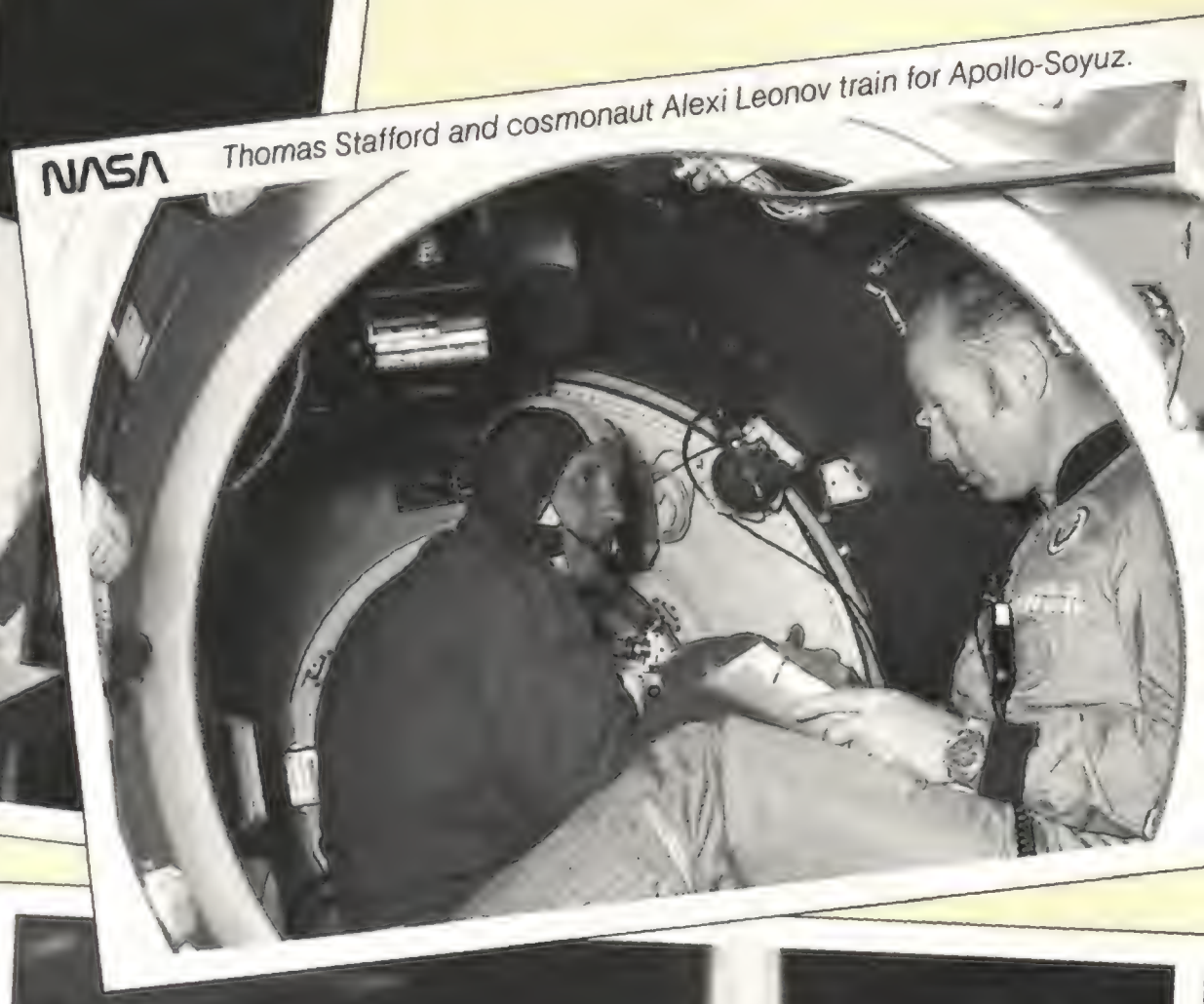


NASA *A geologist's dream: moon rocks.*

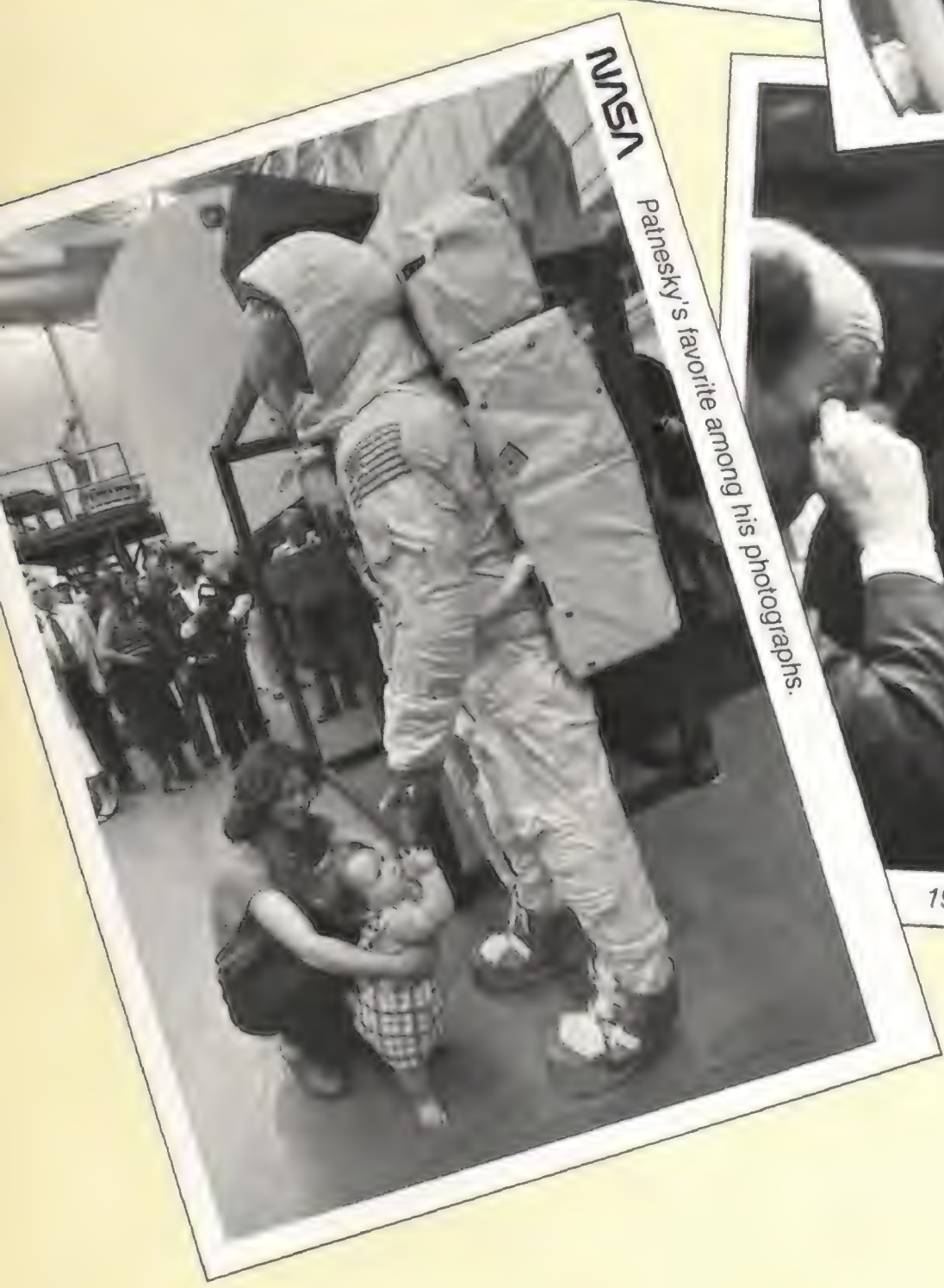
NASA *Apollo 16's Charles Duke is welcomed back by his wife.*

NASA *Greek Orthodox archbishop Iakova in mission control.*

Anwar Sadat and his wife meet JSC director Christopher Kraft.



Thomas Stafford and cosmonaut Alexi Leonov train for Apollo-Soyuz.



Patnesky's favorite among his photographs.

1981: Christopher Kraft guides President Reagan around the JSC.

moment. "At a reception for the Apollo-Soyuz crews," he remembers, "Van Cliburn began to play 'Moscow Nights.' The Russians spontaneously began to sing along. It was very moving, very beautiful. You had to be there." And he found that photographs of Anwar Sadat visiting mission control did not do the Egyptian president justice: "They didn't

NASA Saudi astronaut Sultan Salman Al-Saud (right) and his backup.

Challenger crewmember Judy Resnik.

capture the keen interest and intelligence in his dark eyes."

Of all the photos he has taken, Patnesky's favorite is one of a child reaching out to touch the finger of a spacesuit glove, an image reminiscent of Michelangelo's God giving life to Adam. Other favorites include one of former space center director Christopher Kraft and President Reagan looking up at the mission control tracking map; the striking, black-robed figure of Greek Orthodox archbishop Iakova surrounded by spacecraft control consoles; and, of course, the pre-space center cows.

Patnesky does wish that there was more excitement, more activity, in the nation's space program today. Flipping through Apollo 8 and Apollo 11 photo albums, crammed full of images of excited throngs, flag-waving controllers, and proud, cigar-chomping NASA managers, he says, "Wish it were still like that."

Patnesky's greatest satisfaction comes from his tireless after-hours proselytizing on the gospel of spaceflight. The most cherished albums in his office are those crammed with thank-you notes from ordinary people he's met, talked to, written to, and helped—especially those highly decorated and embellished letters from children, often signed "Future Astronaut."

Like the legacy of his official photos, his albums of grateful letters are precious objects: links to the human side of spaceflight through this unofficial ambassador for space—and the witness to a remarkable bit of history. ✦

NASA Challenger's fatal flight would have been Ronald McNair's second.

NASA Frederick Gregory and Richard Covey react to Challenger's loss.

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OLD GUN

Over the Arizona desert, graying Air Guard pilots undergo a rite of passage at Mach 1.

by Carl Posey

Photographs by George Hall

Wrapped in new armor, the old guard is out to prove that for a fighter pilot, age can be an asset.

Jim Fiorelli swings into the front seat of the F-16 like a stocky knight mounting a familiar horse, repeating the moves he has made thousands of times in all kinds of jet fighters. But measured against the hours amassed in other airplanes, he has spent only the blink of an eye in this cockpit. This sleek fighter aircraft is his ticket to the state of his art.

Lieutenant Colonel Fiorelli, 46, commands the F-16 squadron of the 162nd Tactical Fighter Group in Tucson, Arizona. The 162nd, also a training unit, is one of the first Air Guard units in the country to receive the front-line fighter. The group, like most "schoolhouse" Air Guard units, is a remarkable repository of aeronautical experience, garnered by fighter pilots who have racked up five or six thousand hours, 90 minutes at a time.

The pilots here are instructors in the A-7D Corsair II, a chubby subsonic 1960s machine that has evolved into a lethal ground support system. Before the A-7s the 162nd had F-102 Delta Daggers and F-100 Super Sabres; before that, F-86 Sabres and F-84 Thunderjets. "You know Top Gun?" Fiorelli says as he preflights his airplane. "Well, this is Old Gun."

Old Gun works out of Tucson International Airport in an operations building nicknamed "the Pizza Hut" after its familiar roofline. The decor is southwestern hotel lobby, all terra-cotta tile and big-leaved plants. Ops is populated by gray-haired men in green flight suits, like an occupying force that has abandoned the tensions of military courtesy.

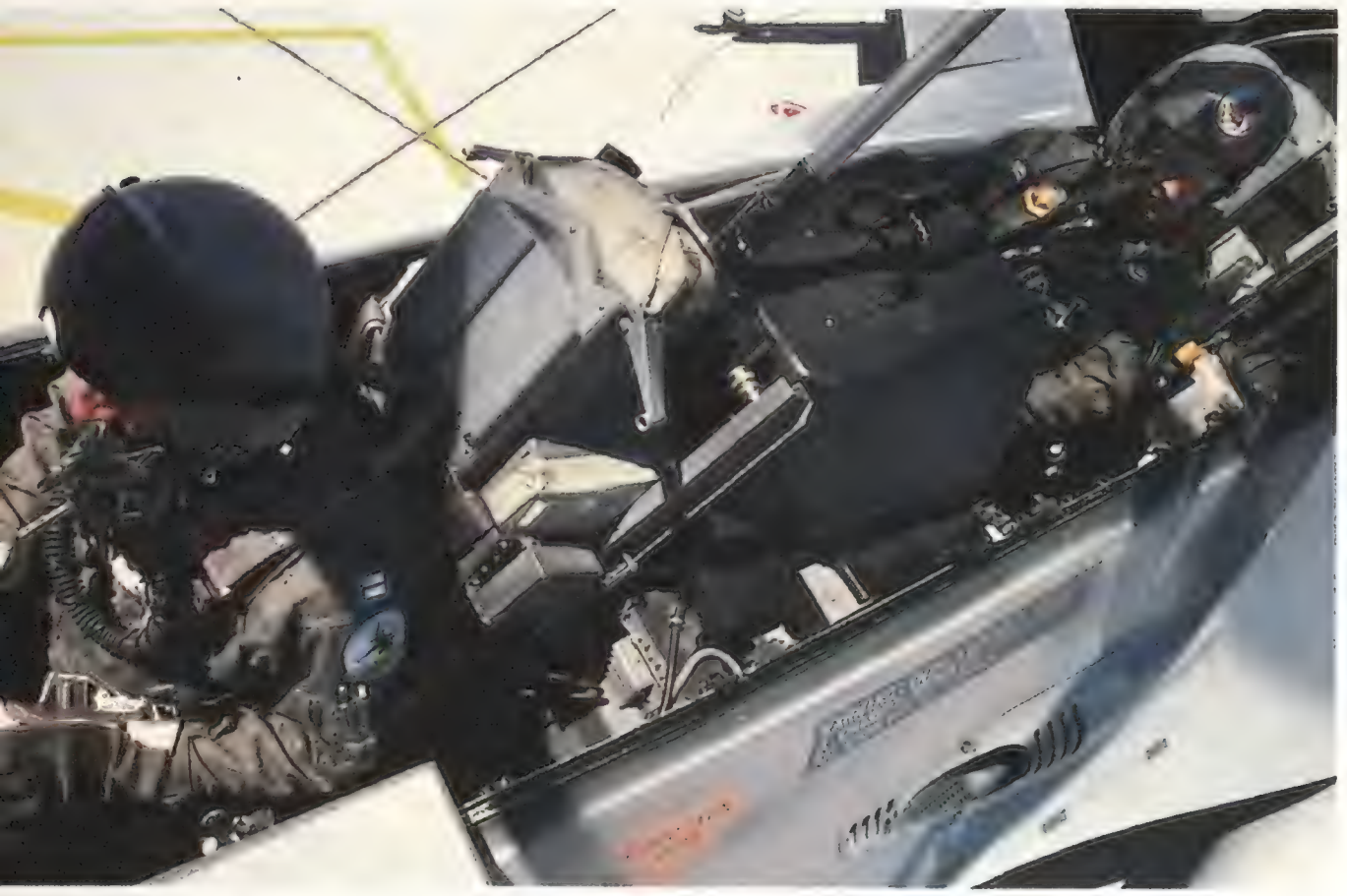
The walls of the Pizza Hut are covered with photographs of airplanes, pilots, and pretty young women. In the ready room is an F-100 seat, upholstered in red leather and set on metal rockers. A gift for a departing commander, the rocking chair was deemed too ugly for a residential living room and was returned to the givers. A model of an A-7 in flight stands on a pedestal at one side of the room. Behind it, in the absence of a model F-16, another pedestal supports a poised yard dart. It's a grim inside joke. The F-16's initial training flights—and crashes—with a fighter wing were made from nearby Hill Air Force Base in the late 1970s. "Used to be, if you had any property in Utah you could eventually expect to get an F-16 in it," a pilot says, "so they called them yard darts."

The kidding cuts both ways. In the ops room a dramatic photo of an A-7 on a bombing run is captioned "Beauty is only skin deep but ugly goes to the bone."

Most Air Guard units have a small cadre of full-time pilots as well as a couple of dozen part-timers—the "weekend warriors" many people think the Guard comprises. In fact, most of these Tucson citizen-soldiers take up arms five days a week, and although part of the Arizona militia, they are paid with federal money, fly federal airplanes, and perform what is generally regarded as federal work. One of the world's largest air forces, the Guard handles about 85 percent of the national air defense mission. An intruder from the north, for example, would most likely be met by interceptors from the Montana Air National Guard. The arrival of the F-16 at Guard bases is one manifestation of a multibillion-dollar move to bring this militia's equipment up to date. By the early 1990s, as many as half of the Air Guard's fighters may be F-16s.

The Guard has always maintained that the real experience resides within its ranks and that all that's needed to prove its superiority is new aircraft. The F-16 gives the Guard the opportunity to do so, and also to demonstrate that age is no handicap. The Old Gun pilots gamble that their thousands of hours in jets will give them something of an edge over younger pilots who consider 9 Gs routine.

Certainly no one in the Guard thinks age is a problem. "It depends on your physical condition," says Fiorelli. "Pilots are usually the healthiest people in the country, and then they vary some within the group: guys that run the Iron Man competition, guys that do nothing. Back when we were flying in Vietnam we did three sorties a day, then went out ripsnorting all night. Now I fly three times, go home, and go to bed at nine. That's the difference between Top Gun and Old Gun. We still gun the brains out



A Montana Guard student straps into a high-G, high-tech classroom with instructor Jim Fiorelli (rear).

of them but then we go home and go to sleep."

"In World War II the concept developed that flying fighters is a young man's game," says Lieutenant Colonel Robert Cassaro, who soloed the F-16 in February 1986, on his 53rd birthday. "But I know better how to look, how to compensate for my eyes being less than they used to be. My knowledge of the geometry of the fight makes me superior to a younger pilot."

The argument seems to hold up. The old hands in the A-7s have bested F-15 students from Luke Air Force Base in air-to-air gunnery, and in 1985, vintage F-106s from the Montana Air Guard beat Air Force F-15s for the coveted Hughes Trophy, awarded annually to the best air-to-air defense unit.

Everyone in the 162nd wants to fly the F-16, but for now only 12 can be accommodated: the commanding officer, his deputy, and the 10 men in Fiorelli's squadron. This favored dozen has opted for the Next Thing in Flight, a choice they have made time and again throughout their careers. The choice of jet fighters above all else is their common denominator.

Fiorelli, an Air Force Academy graduate, moved to the Guard when the Air Force took him out of F-104s and put him in B-52 bombers in 1972. Cassaro, who flew F-100s in Vietnam with Fiorelli, says he passed up a command job to get in the F-16. "We've *always* been F-16 people," he says. "I've been an F-16 pilot for 31 years. They're just now becoming available to me, that's all." Today's wingman, Major Rock Massey, is a ruddy, quiet man who also flew F-100s with Cassaro in Vietnam. He left military aviation to test-fly Learjets until the implacable gravity of jet fighters pulled him to the Tucson unit's A-7s.

In the front seat of this vehicle of passage, Fiorelli drops the canopy to keep the gaping intake beneath the fuselage from sucking in maps, pencils, and other cockpit accoutrements. This also allows him to start up the air conditioner, considered a life support system in the 95-degree desert air. Massey cranks up in the adjacent airplane. The two pilots have about as much time in the F-16 as most students have in a Cessna 152 before their check ride. While it is not in the nature of pilots to make much of risk or new machines, Fiorelli's voice betrays excitement, perhaps affection, as the airplane's systems come alive.

The four computers governing the inherently unstable airplane are collectively called HAL after the able but mad computer in *2001: A Space Odyssey.* At startup, HAL runs through 54 queries that tell Fiorelli and Massey which systems are fully functional and where today's glitches are. When HAL tells Fiorelli the airplane is flightworthy, Fiorelli tells ground control, "We've got two pizzas to go." He is Pizza One; Massey, Pizza Two.

In a pod of idling F-16s and A-7s, Fiorelli tests the various weapons displays. The headphones burble like a video game as the systems run through their electronic vocabularies on threats, the head-up display (HUD), and the radar display. A weaponry check adds the sensing snarl of the Sidewinder missile head and inert motor mounted on the right wingtip.

When Pizza One is cleared for takeoff, Fiorelli throttles up and lights the afterburner. Clear of the runway, he pulls into a 60-degree climb. The G-suit that squeezes blood up from the lower body to maintain consciousness contracts painfully.

G forces figure prominently in this rite of passage (see "High Gs, High Risk," October/November 1987). The normal force of gravity is 1 G. In the A-7, tight maneuvering can increase this sevenfold, but the airplane is not powerful enough to sustain this level for more than a few seconds. The F-16 is built for high-G flight. "Light the afterburner below 10,000 feet and it'll pull 9 Gs until it runs out of gas," Fiorelli says. "You can get 30 to 40 seconds of unrelieved 9 Gs. You get short, squatty guys like me—I can go to 9 without graying out, and I could probably do 11. You just use it when you need it."

Cassaro's view of G forces is more combative. "I usually try to go to 9 Gs every flight," he says. "You can develop the ability to resist high Gs but it goes away in a couple of weeks if you don't use it."

"G-awareness is a big part of our training," says Lieutenant Colonel Richard Rose, assistant director of operations at the 162nd. "The F-16 can bite you. You get pitched back and pass out for 20, 30 seconds—in a fighter, that puts you in the ground. We do 4 to 6 Gs, then 6 to 8, and then we ask for a G-loss rest. Loss of consciousness seems to oc-

cur after the first two engagements. The fatigue seems to build up in people. So you take a rest, remind yourself where you are."

Rose likes the F-16, but one senses it is not the girl of his dreams. For one thing, he doesn't think much of having the control stick on the right side of the cockpit instead of on a center pedestal. Transducers in this control stick interpret the pressure of the pilot's grip as the degree of movement desired, so the stick itself moves only an eighth of an inch, like something not properly nailed down. "Here, in strafe, you squeeze the trigger and the nose comes up," says Rose. "And after 6,000 hours I can't bring myself to turn loose of the stick when I'm close to another airplane. We had a night tanker operation and the boom operator needed me to dim the refueling receptacle lights behind the cockpit. With a conventional stick I could just change hands to reach the switch. But here I had to release the sidestick and reach down behind it. I didn't like that."

But most pilots like the sidestick. A few tentative turns and you begin to feel that your brain is talking directly to HAL, that the stick is just something to hold on to. But it bristles with possibilities—a trigger, target designator, weapons release. So does the throttle, which is operated with the left hand on its knobby head so the pilot need only move forearm and fingertips—about all you *can* move at 9 Gs. The dogfight switch toggles to either cannon or missiles and bombs with a touch of the thumb. The microphone switch is operated by the left ring finger. ("After 20 years of using the thumb on the radio switch, they moved it to this finger," Fiorelli laments.) Manipulating these switches is called "playing the piccolo," and as Massey says, "If you don't know how to move your fingers, you can't use your avionics."

Moving up to the F-16 fundamentally alters the tactical world of the A-7 pilot. It increases enormously his number of options and the speed at which he can execute them in any engagement; it also adds a vertical dimension that enables a climb through 40,000 feet at 400 knots. An A-7 pilot jumped during a bomb run has little choice but to jettison his bombs, turn defensively to meet the attacker, and attempt an escape. "We're pretty good at defense," Major Jerry Wilper explains. "We've had a lot of practice." An F-16 on the same mission can swiftly take the offensive.

Kim Barnes/Stansbury, Ronsaville, Wood Inc.

For Tucson's Old Gun, this option means a new and unfamiliar emphasis on air-to-air combat. Fiorelli, Massey, Cassaro, and the other veterans in the 162nd have flown hundreds of combat sorties but most were ground support missions, which rarely involve encounters with enemy aircraft. And while the Guard's A-7s have a computer-guided mode for ground attack, they have no air-to-air radar capability, no HAL to point you at the enemy, and too little thrust to be an effective counter-offensive airplane.

Now, like knights banging playfully on their opponents' shields before a joust, Fiorelli and Massey test their weapons and radar in practice intercepts of each other's aircraft. Seven miles or so above the stark browns, blues, and golds of the desert, in a 50- by 30-mile chunk of military operations airspace called Morenci One for the mining area beneath it, Fiorelli turns southward and Massey heads north.

Both pilots have selected north and south ground points as reference for

their radar and have fed these coordinates to HAL. In a ground-controlled intercept, relative positions of the target and interceptor would be radioed to the pilot based on these ground points. But the F-16 can calculate this information on its own, with the HUD and radar displaying heading, distance, airspeed, altitude, and closure rate.

"Mainly you're trying to develop search patterns to get a lock on and analyze the information coming off a radar screen," Fiorelli explains. He and Massey are so new to the F-16 that its electronic prose, given the time they have to read it, seems as dense as a page in *Tristam Shandy.* "The skill is in getting locked on," says Fiorelli. "You have to sort, plan, deploy, get your tactics together. Get your internal clock and systems management going. You waste five to seven seconds doing something you shouldn't—two, three, four seconds is a long time to a fighter pilot."

Fiorelli turns toward Massey, more than 30 miles away. Massey is the target on this first run, and plays ground controller to draw Fiorelli toward the arena. "Bandit 340 for five, angels 20." This pinpoints Pizza Two at 340 degrees and five miles from the ground point at an altitude of 20,000 feet. "We're new to this, so we try to use the terminology," says Massey.

The radar screen down where Fiorelli used to have a control stick shows Pizza Two as a diamond, the ground point as a cross. The closure rate readout shows 1,114 knots. At 20 miles Fiorelli bids for more turning room, easing out of the head-on trajectory, and Massey takes over as the aggressor. "We use standard tactics," says Fiorelli. "We're trying to get timing now. Distance from other airplanes, trying to get into the six o'clock position at seven to nine miles. Head on, your closure rate is about 1,200 knots, and time in that window is very short. Coming in, our face shots are not usually kills. So we press on into the merge, into visual range. F-15s are so big that generally we get the first maneuver before they pick us up. These are usually

A-7 ground support pilots must fly defensively; the F-16 opens a new arena of air-to-air offensive tactics.

The tie that binds Old Gun pilots, in and out of the cockpit, is a singular devotion to jet fighters.

younger pilots, less experienced." Then, grinning, he adds: "Of course, anybody we fight would be younger and less experienced."

The range between Pizzas One and Two has shrunk from miles to meters. Until now the fight has been airplane versus airplane, the violence masked by distance and technology. Now it turns personal. "When you get in close, you can see the guy in the other cockpit and it becomes you against him," says Fiorelli. "When you go against a real enemy fighter, you think, *That guy's trying to kill me, I'm trying to kill him. That's why we're here.*" These men are not sparring above the Arizona desert in F-16s just because they can fly, any more than prizefighters are in the ring because they are fine athletes. There must also be the willingness to unleash the lethal fist, an essential difference between jet pilots and jet fighter pilots. Today, although the big soft gloves are on, both pilots want to make this a worthwhile fight.

Fiorelli says "Visual contact" and Massey flashes by, perhaps 2,000 feet overhead and not quite where he wants to be, and begins a rolling turn to the right. Pizza One rises after him on afterburner, and the intercom broadcasts heavy breathing as the G-suits inflate. A half-roll to the right and Pizza One tries to slide in behind the attacker. But the fight eventually deteriorates into a decisionless spiral. "Two like airplanes tend to wind up in a slow spiral," Fiorelli explains, "whether you're talking SPADs or F-16s."

The airplanes return to their corners for another engagement. This time, as Fiorelli turns behind Massey, he cranks Pizza One into an 8-G turn. A Sidewinder sensor growls in the headphones, indicating the missile is locked on Pizza Two. Fiorelli, a note of cheer in his voice, calls "Fox Two," which tells Massey he is being fired at. The dogfight continues into a spiral. The third engagement ends inconclusively, with violent effort but no kills.

The battle in Morenci One is also between two pilots and time. Fiorelli and Massey are discovering where they are in terms of skill and where they have to be to teach others to fly the airplane. In two months they will be covering this difficult ground with their first students, a dozen Air Guard pilots who have been flying F-106s. Today, however, they are keenly aware of lagging behind their machinery.

"The first couple of hundred hours in the A-7, I felt I was behind it all the time," says Jerry Wilper. "We're at that point in the F-16, where you do something about three seconds after you need to. We're coming out of an airplane with a lot of time in it, where we can fly our plane and the planes of a couple of students besides. Right now we're struggling to keep up with our own plane. But . . . we know where we have to be."

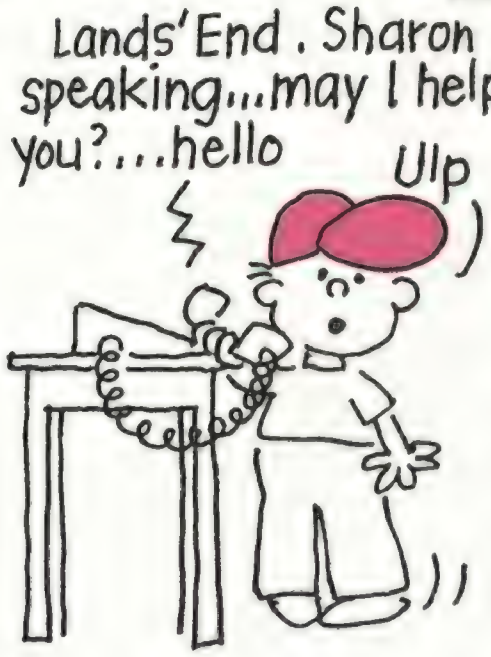
Later, in a darkened classroom, Fiorelli and Massey review the videotapes of their engagements. An onboard camera alternately taped the HUD and the radar, and on the TV screen the HUD readouts weave and spin as Fiorelli and Massey roll and dive and climb into what winds up as the slow spiral of a draw. There remains a faint jitteriness from the day's encounters. Fiorelli has most of the day's best moves. Massey notes that he was a little out of position here, a little slow there.

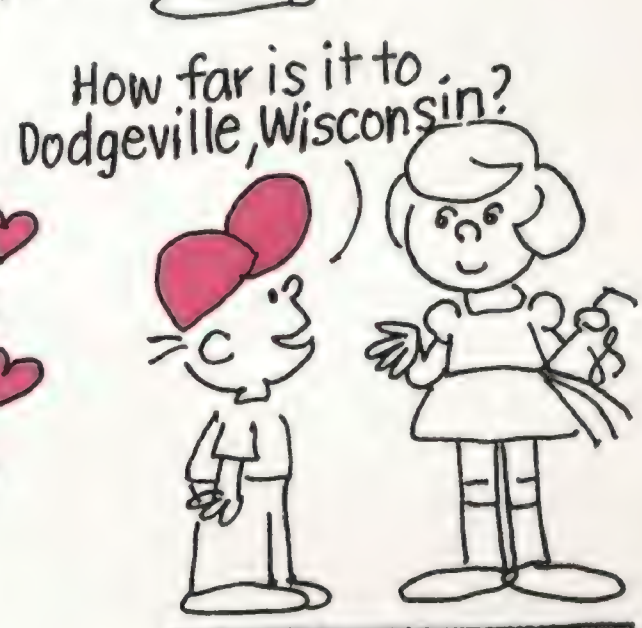
Other pilots arrive with tapes. One of them has been out against an A-7. On tape, the stubby A-7 is trapped in the F-16's sight reticule for what seems like an eternity. It is a poignant image, this capable airplane so helplessly and fatally suspended. The pilots view it impassively. The familiar sparrow shape of their old mudbeating pal is as far from their hearts now as one of the Soviet jet fighters pictured on the walls of the Pizza Hut.

They have crossed over. They fly the future, and everything else is the past.

The first dozen F-16 pilots in Tucson went on to become first-chair piccolo players and have taught F-106 Guard pilots from the Florida, New Jersey, and Montana Fighter Intercept Groups, as well as F-4 pilots from the Arkansas and Kansas Tactical Fighter Groups. "We're very comfortable in the airplane," says Fiorelli, who now has over 600 hours in the F-16. "Processing the information, calling up the right radar mode, the right missile—it's all becoming fully automatic. When a guy calls me because something's not happening, I know immediately what's wrong. Usually it's what we call 'common student errors.' We've seem 'em. We've made *'em." And in the Pizza Hut's ready room, the yard dart on the pedestal has been replaced by a splendid model of the F-16.*

Tim Falls in Love





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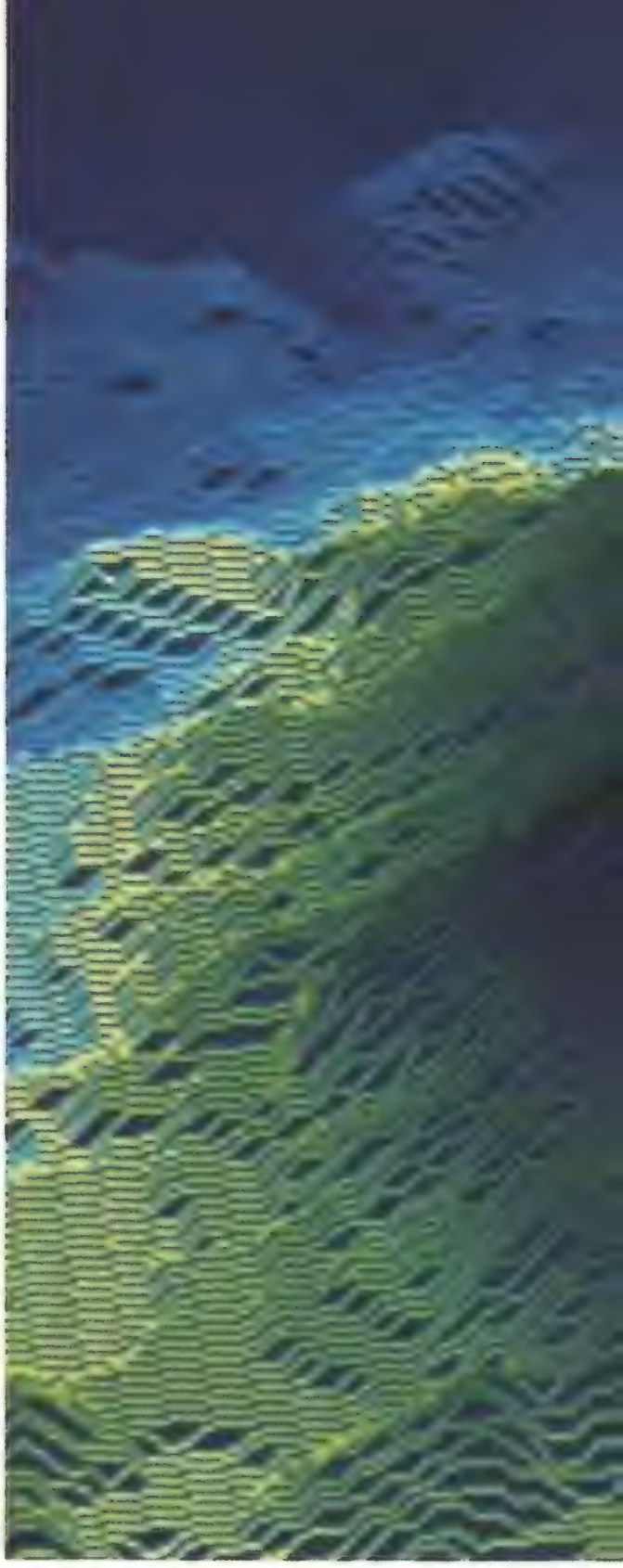
Looking Down on History

Neither rainforests nor mountains nor poisonous snakes can keep airborne archeologists from their appointed digs.

by Richard Wolkomir

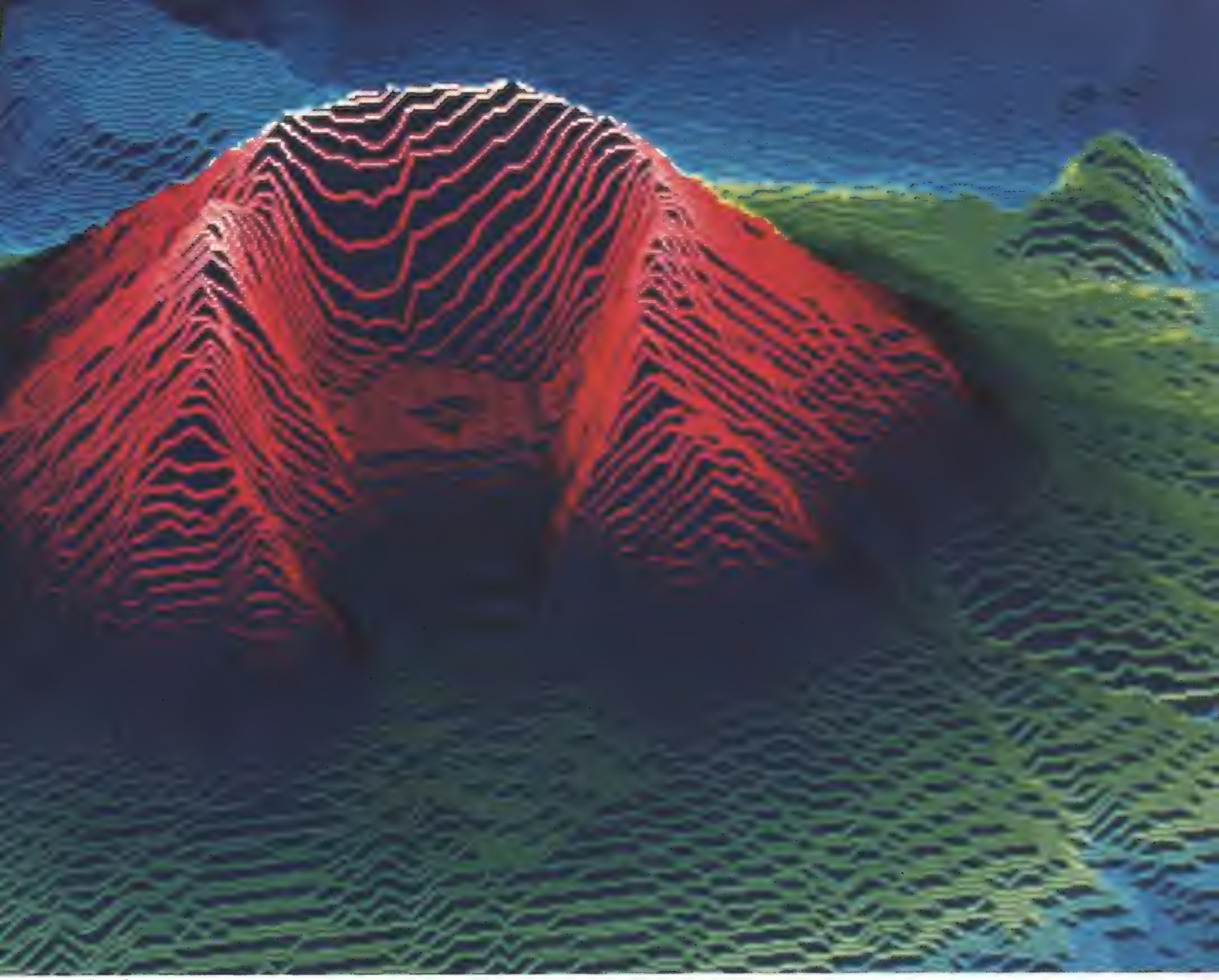
Payson Sheets



Last February a Gates Learjet 23 flew an unusual mission over a volcano in the Costa Rican rainforest. As the NASA aircraft banked, turned, skirted the volcano, and turned again, multi-spectral scanners in its belly were searching for signs of the people who had lived and died in the area more than a thousand years ago. The survey, NASA's third of the Arenal Volcano site, was part of an ambitious campaign to catapult trowel-and-sieve archeology into the Space Age.

NASA archeologist Tom Sever made his first aerial survey of the site in 1984, using a lidar (light detection and ranging) instrument. His second survey, done in February 1985, was aboard a

The view from above is reducing the sore backs, sunburn, and blisters of old-style archeological excavation.



Stennis Space Center

Computer processing of topographic data reveals the results of Mount St. Helens' 1980 eruption.

Convair 990 aircraft containing an L-band radar. The lidar and the L-band radar can pierce the densest forest cover to produce highly detailed topographic images of the terrain. Other types of sensors, like the thermal infrared multi-spectral scanner, can reveal the composition of surface features. Infrared sensors can aid archeologists by recording fraction-of-a-degree variations in the heat radiating from different objects and substances, as well as heat emission rates. "Every substance has its own spectral signature," says Sever, "like a fingerprint."

He has been called NASA's Indiana Jones, but Sever is no adventurer. He merely wants to convince archeologists that advanced sensors mounted on aircraft and satellites will help them discover what would otherwise remain impossible to detect. "Remote sensing will be to the '80s what radiocarbon dating was to the '50s," Sever claims.

A humorous man who stands over six-foot-four in cowboy boots, Sever is unique at NASA. "I'm NASA's premier archeologist," he tells visitors to his office at the Stennis Space Center (SSC) in Mississippi. "Actually," he adds, "I'm NASA's *only* archeologist."

Sever's office reflects his trade. The walls are covered with photos of ruins entwined in a stranglehold of vines. Copies of Mayan and Incan sculptures line his shelves. Behind his desk leers a skull wearing a pith helmet tipped at a jaunty angle. It's a plastic model, but it still grabs people's attention, he says.

In April 1985 Sever returned to the Arenal site, intending to use the results of the second aerial survey to uncover some ancient history. There to greet him was University of Colorado archeologist Payson Sheets. Sheets had been working at Arenal since 1981, after a colleague had spotted what he believed were prehistoric pottery shards near Arenal Volcano.

The volcano had erupted nine times in the past 4,000 years, and Sheets was investigating how volcanic activity has affected societies. He also wanted to determine when village life began in Costa Rica. An archeological traditionalist, Sheets believed in an Eleventh Commandment: Thou shalt not neglect spade-in-the-dirt fieldwork.

When Sever arrived, Sheets was in the midst of surveying the region on foot, finishing each day by picking off the hundreds of ticks that had burrowed into his skin. Sheets was having an uncomfortable time, but he doubted that

Sever could replace the legwork and its miseries with an airplane ride. "Costa Rica is probably the worst possible site for remote sensing," Sheets says now. Prehistoric populations were thinly distributed throughout the area, leaving few marks. The dense jungle, its canopy reaching as high as 150 feet, obstructs airborne viewing. And Arenal's eruptions have buried most ancient settlements. "If remote sensing could work here," Sheets recalls thinking, "it could work anywhere."

Sever showed Sheets the imagery from the February Convair flight. "What's this line?" Sever asked. "It's a fence line," Sheets said, remembering one of his hikes. "No, I mean this fainter line running alongside it—I think it's a road," said Sever. *Sure,* Sheets thought, *you can find a road just about anywhere.* "But I didn't tell him what I was thinking, because I wanted to be a gracious host," Sheets recalls today. "I tried to humor him."

Caroline Sheen

Tom Sever (left) and Payson Sheets turn to computers for clarifications of aerial sightings.

So he went ahead and excavated in the areas Sever had pointed out. He discovered that Sever's "roads" were actually ancient footpaths. Thousands of years old and buried under several layers of volcanic ash, the paths had nevertheless slightly altered the soil lying over them. They had affected surface erosion, which in turn changed soil content and moisture in a pattern reflected by the vegetation. As a result, the level of infrared light radiated from plants growing over the paths differed from that of adjacent plants. Sensors picked up that difference, enabling Sever and Sheets to detect the footpaths through layers of earth and, in a sense, to look back through time.

Courtesy of the Museum of New Mexico

Charles Lindbergh ushered in the age of airborne archeology in 1929 when he photographed Chaco Canyon.

Sheets and his colleagues have now started assembling a picture of Costa Rican life thousands of years ago. "Before, we studied only isolated villages in Costa Rica, but the footpaths show a regional network," Sheets says. The archeologist has found that people lived in hamlets that, while mostly independent, were tied by religious activities.

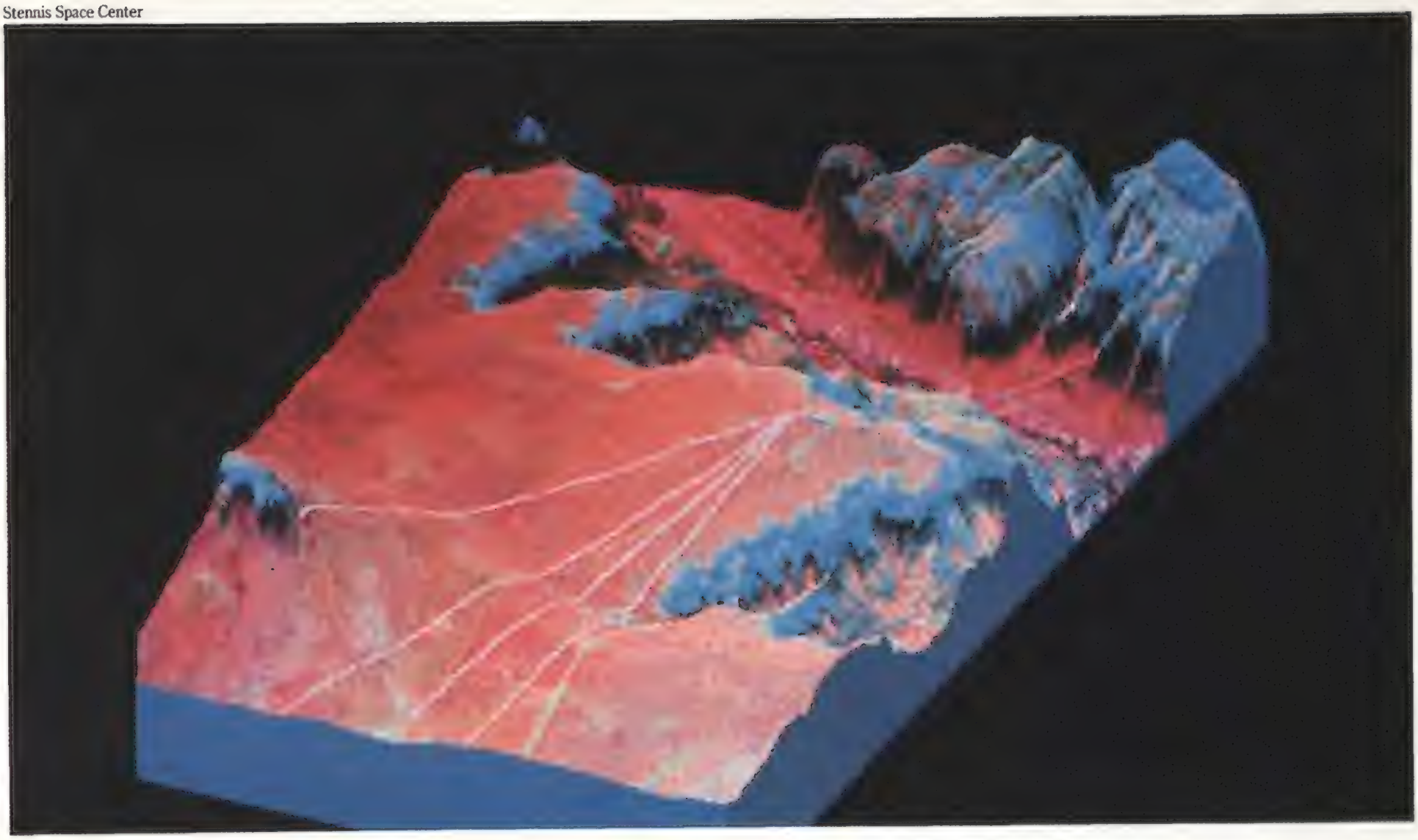
"Without aerial sensing we'd never have found those footpaths," says Sheets. "Once I got over the idea they couldn't be found, I looked at aerial images made elsewhere, like North Dakota, and began to see what could possibly be footpaths"—linear anomalies that appear to connect archeological sites. "In Costa Rica we can spot them now with about 85 percent accuracy."

Sever was no novice at the art of image interpretation when he first presented his ideas to Sheets. He had gained practice discovering buried roads from the air at New Mexico's Chaco Canyon, an ancient Anasazi Indian site that was the subject of one of the earliest aerial archeology surveys. In June 1929 Charles Lindbergh flew over the canyon and snapped black-and-white photographs for archeologists who were studying the early history of the region.

Lindbergh didn't see any roads himself, and through the 1930s and '40s sheep and goats overgrazed the area, blurring any signs of early settlements. But in 1971 rangers at Chaco Canyon National Park looked over the Lindbergh photos and noticed straight lines crossing the desert, each marked by vigorous vegetation. As a result, the U.S. Bureau of Land Management sent 10 researchers to Chaco Canyon to study the lines the old-fashioned way. The team spent three years trekking around the area, concluding that the lines lay over Anasazi roads.

Sever came to work at the Stennis center (then called National Space

Stennis Space Center



The combination of topographic and satellite data from Arenal exposes ancient footpaths buried by ash.

Technology Laboratories) in 1978, but he wasn't too involved in aerial sensing. The technology of the 1970s was not precise enough to unveil features of archeological interest. Then, during two weeks in 1982, he experimentally duplicated the Bureau of Land Management's three-year study. Using a NASA Learjet armed with a thermal infrared multi-spectral scanner, Sever spotted the lines from the air and separated spurious ones from actual buried roads. After his Chaco Canyon success, NASA began taking the notion of aerial archeology seriously, and Sever's work shifted into high gear.

Remote sensing has come a long way since Lindbergh's aerial surveys. His black-and-white photos recorded visible, or white, light. Multi-spectral scanners used for airborne and space-based sensing can collect data in several narrow bands corresponding to the different colors that make up white light, plus infrared.

One archeological application for such scanners is detecting buried construction, like walls or roadways. Buried stone can block the roots of surface vegetation, affecting its growth and therefore its infrared signature. "In the morning a buried wall stays cool longer than its surroundings, and scanners can pick up that tiny temperature difference," says Kenneth Cashion, SSC's aircraft data acquisition manager. "Archeologists can guess it's a buried human artifact because God doesn't do things in straight lines."

In November 1981 a new space-based remote sensing instrument called a shuttle imaging radar (SIR) demonstrated that microwaves can unveil features buried under desert sands. Beaming down waves from the space shuttle, SIR-A penetrated the Sahara to reveal what appeared to be a network of riverbeds. SIR-B flew on a mission in November 1984 and confirmed what the first had uncovered. Digging down to the riverbeds, geological surveyors from the United States and Egypt later found 250,000-year-old stone axes.

The SIR experiments were initially designed to assess environmental conditions on the ground, explains Jet Propulsion Laboratory official Charles Elachi. But because the SIR imagery turned out to be useful to archeologists, SIR-C, to be launched on two shuttle flights in 1991 and 1992, will map sub-Sahara riverbeds for both archeologists and environmental scientists.

Sensors that scan the earth from above usually produce digital data that must be processed by computer before archeologists can make any sense of it. Computer processing also enables archeologists to blend imagery from different wavelengths and techniques into a single multi-layered image. With the right kind of software, old-fashioned mapping data can be combined with digital imagery. "We can even use complex mathematical procedures to manipulate data from sensors to reveal new detail that wasn't apparent in the original," Sever says. He notes that the remote sensing technology does not harm the environment in any way and will produce data archives on sites that are now relatively untouched but that may be altered or even ruined in the future.

Image processing can single out and highlight certain features—a family of

Bobby Gray, JSC

NASA's Learjet hauls highly sensitive instruments over rugged terrain on flights of exploration and discovery.

trees, for example. "Here's Kansas City," Sever says, typing in a command on his computer. A black-and-white satellite photograph of the city appears on the screen. "This picture contains 256 shades of gray, but the human eye distinguishes only about 10 or 12 .... Now where are the oak trees?" Sever taps keys, producing large black swaths on the screen, which indicate the city's oaks. "What about water? Let's go to infrared." Like a kid with a new toy, Sever punches the computer keyboard and the picture turns red, with black spots marking reservoirs, rivers, and ponds. Vegetation appears red because it bounces back radiation in near-infrared wavelengths, he explains. Water absorbs near-infrared and appears black.

A research team led by forestry professor Frank Miller of Mississippi State University has located three ghost towns in Mississippi by looking for osage orange, crape myrtle, and white oak trees, ornamental plants that are a sure sign of human society. "We build a database of what we know about a people," says Sever, "and then we can add that to the remote sensing images."

New instruments now in the works will do even fancier tricks. Sever has been thinking about a scanner that could detect the electromagnetic signature of phosphate pollutants in soil. "Humans always deposit phosphates in the form of carcasses, urine, decomposing huts, and this machine would detect those phosphate deposits," he says.

Even without his dream machine, Sever's archeological remote sensing is attracting attention. He has received more than 300 requests from professional and amateur archeologists to help them hunt for everything from sunken World War II submarines to Noah's Ark and signs of civilization on Mars.

One archeology project to which Sever will bring NASA's remote sensing expertise is a study of northeastern Peru's Rio Abiseo region, which Payson Sheets describes as one of the most inaccessible areas in the world. To get there, says Sheets, you drive to the end of a road. "Then you hike as hard as you can for four days, climbing through huge glaciated valleys above 10,000 feet. The site has been abandoned since the Spanish conquest, 500 years ago, and it's never been looted, so there are pots on the surface and mummies."

The Rio Abiseo study team, led by Tom Lennon of the University of Colorado at Boulder, will first use remote sensing data to map the currently uncharted area. The researchers will use the imagery to look for pre-Incan stone roads, large stone buildings, and hillside terracing indicative of agriculture. "We might use radar because it's sensitive to straight walls and right-angle turns and because a lot of the area is rainforest, where the heavy vegetation and cloud cover make conventional photography hard to use," Sheets says.

Caroline Sheen

Gorgeous it's not, but the thermal infrared multi-spectral scanner makes beautiful pictures for scientists.

The Odd Couple of Arenal, Sheets and Sever are already collaborating on new digs.

Scott Madry, an archeologist with the Institute for Technology Development, a nonprofit research organization that runs the Space Remote Sensing Center in Mississippi, is also practicing his trade from the air. One of his current projects involves piloting a single-engine Cessna 172 over the fields of Burgundy in France and photographing Celtic and Roman remains. He combines the results with digital data collected by airborne digital scanners and U.S. and French remote sensing satellites, as well as with data collected by researchers on foot. Time is running out: an expanding gravel mining operation has already eaten up one of the French sites.

Madry also is using pictures taken by a large-format camera that flew on the shuttle in 1984. The camera took detailed photographs of canals and other Incan remains along the Peruvian coast. "Archeologists were blown away by what you can see," he says. A private company is selling the photos for NASA and prices are steep, but Madry says the company has donated photos that will be used for the Peru study. Now that companies rather than government agencies are distributing remote sensing data, high prices are a fact of life—SPOT imagery for the Burgundy project has cost $3,400 so far. But "remote sensing gives you information that's otherwise unavailable, and over a wide region," Madry says.

"There's a danger of letting remote sensing take you into a high-tech never-never land," says the traditionalist Sheets. "I don't think remote sensing is going to let you just sit back in your easy chair and pull up data—there has to be a big field component." Fieldwork carries risks: in Costa Rica a pit viper struck out at Sheets as he jogged past its lair. ("It wasn't any big deal," he says; "it missed.") And one of his colleagues was stung twice by a scorpion as she slept. Although he downplays the danger, he admits that remote sensing can be a powerful adjunct to work done on the ground. Archeology remains a digging science, but its future is looking up. ✈


NASA

Harvesting the Wind

These spinning blades may look like airplane propellers, but they don't consume energy: they capture it.

by Berl Brechner

April 3, 1987, happened to be a particularly good day for wind in California. Summer weather patterns had taken hold: as the sun heated the land, hot air rose over the inland deserts, drawing a cool wind eastward from the Pacific. By dusk, the wind had intensified to 40 mph, sometimes more, then it diminished before dawn. After the calm, by 8 or 9 a.m., the cycle began again, the wind's speed higher where it rushed over hills and coursed through passes.

At some of these passes the rushing wind set a chorus line into dazzling motion: throngs of windmills began transforming the wind's energy into electricity. Long white blades flashed sharply in the sun like a thousand amateurs trying out for the Rockettes. Some twirled like tops, others spun like frenzied pinwheels. Some faced the wind, others turned their backs to it. Even in strong winds, some spun at a placid rate of 40 rpm, while others seemed crazed and agitated, their blades churning at three and a half times that rate.

On that April day, all that motion paid off: the dancing, spinning blades of the 4,000-plus windmills near Tehachapi produced over 200 megawatts, more wind energy for the Southern California Edison Company than had ever been produced there. It was enough to supply power to the whole Antelope Valley, including Tehachapi, Mojave, Lancaster, and Palmdale, with the surplus flowing to Los Angeles.

These commercial machines are a far cry from the small, homebuilt windmills advertised in the back-to-the-land and pop-science magazines a dozen years ago. Today, wind turbines with rotors spanning 50 to 60 feet predominate, each producing enough electricity to meet the needs of 40 to 50 homes. The machines' grandeur comes as more of a surprise. Viewed from afar, the wind machines look puny, no more than tiny towers along the horizon. But most stand as tall as 10- to 15-story buildings.

Large clusters of wind turbines are known as wind power plants or wind farms. The farms, privately owned, generate electricity for sale to local utilities. In the United States wind farms are found largely in California, whose geography and weather have made it the focus of wind energy development. The state is carved with mountain passes where strong winds blow steadily; big cities are nearby to gobble up the electricity. Last year California produced approximately 90 percent of the world's wind energy, much of it at wind farms developed around three major passes: Altamont Pass, east of San Francisco, Tehachapi, north of Los Angeles, and San Gorgonio Pass, east of Los Angeles.

In California, too, critics of traditional power sources—nuclear stations and coal- and gas-fired steam turbines—are notably more active. Plans for alternative energy sources find strong backers. California's wind power plants began dotting the hillsides in 1981, when new regulations paved the way for producers of alternative forms of energy to sell the energy to utilities. These measures finally allowed investors to take advantage of tax credits established in 1978 to encourage the development of such new energy sources. In fact, because tax benefits—a 15 percent development credit and a 10 percent investment credit—went to investors in the year their machines were put into service, the last quarter of each year saw a flurry of wind turbine installation.

The tax credits expired at the close of 1985, bringing a few

Rich Turner

Today's huge windmills merge ancient technique with modern know-how to transform wind into electricity.

Wind turbines bristle on the bare hills of Altamont Pass, outside San Francisco (opposite). California produces the vast majority of the world's wind power.

Kevin Schafer; Tom Stack & Assoc.

A new twist on an old theme, Darrieus-style windmills have long, bowed blades that spin around a vertical axis.

Christopher Springmann

especially hectic months before the year's end: construction crews worked double shifts erecting scores of machines each day. In a few cases developers pressed helicopters into service to hoist turbines into place to speed assembly. By the end of the year, 4,590 new turbines had been installed, bringing the total in California to over 13,000.

The industry's growth has slackened considerably since then, and many companies have been pushed out of the business. In 1986, 1,825 new machines were installed in California; the following year, 1,392.

The loss of tax incentives still irks wind energy proponents. Subsidies, depletion allowances, and special exemptions are still in place for producers of competing forms of energy: nuclear, gas, and oil. "Cut out all the special treatment," suggests Dan Juhl, a wind turbine designer. "Put us all on a level playing field and we're more competitive than any other power source. We have no way to go but up. We can put up as little or as much capacity as needed, and do it fast—and add more later if it's needed."

Wind farm productivity, however, has continued to increase as manufacturers improve on earlier designs. Wind energy production in 1987 was up 165 percent from 1985. Machine reliability is now above 90 percent for the better wind plants, which means that if the wind blows at suitable speeds, nine out of 10 machines will be ready to catch it. And ever since April 3, 1987, 200-plus megawatts of energy generation has become commonplace for the thousands of wind turbines at Tehachapi.

Last year California's wind farms churned out 1.7 billion kilowatt-hours of energy, a savings of about three million barrels of oil to the two utilities that buy it, and a revenue of about $130 million to the wind plants that generate it. Those kilowatt-hours represent the annual electrical needs of about 280,000 households.

During the first couple of years of the California wind rush, failures were common. "Rotors used to destroy themselves, just like wings falling off airplanes," says Paul Gipe, a wind energy consultant. "Seven years ago it was news when a turbine ran well—when they'd run for six weeks continuously or 24 hours in a high wind. Now it's news when they fail. That says a lot about how far this industry has come."

In the United States, where wind energy must be priced to compete with more conventional energy sources to survive, keeping expenses down can take precedence over making technological improvements. "There are probably a dozen things that you can do to increase performance of a wind turbine," says Peter Lissaman, a vice president of AeroVironment, Inc., an innovative Monrovia, California firm that has been heavily involved in wind energy development. "But they are rather costly. These are not military airplanes. You are not going to pay more than it's worth to improve performance." The goal, suggests Lissaman, who worked on the aerodynamics of Paul MacCready's human-powered *Gossamer Condor,* "is to capture wind power not with the greatest aerodynamic efficiency but with the greatest economic efficiency."

While the basic task of the wind turbine may be obvious—to turn a stiff breeze into electricity—several seemingly conflicting styles of machines often work side by side. Weather patterns, cost of construction, site limitations, and generator size

Dale Glasgow

Lift created behind a wind turbine rotor pulls the blade sideways to start it spinning; lift in front *of an airplane propeller helps pull the craft forward.*

Helicopters were enlisted to speed wind turbine installation at the height of the wind rush in 1985 (opposite).

Paul Gipe

Guy Motil/West Light

Steady winds through San Gorgonio Pass power a lone surfer—and thousands of homes.

are factors that may favor one style over another.

The most common wind turbine style is the prop type, called a horizontal-axis machine by the industry. Its rotors are commonly made of fiberglass. Despite their resemblance to airplane propellers, the rotors' function, and thus their design, is the exact opposite. While the airplane propeller is rotated by an engine to produce thrust, wind turbine blades receive thrust in the form of wind to turn the shaft of a generator. On a wind turbine, the longer, curved side of the blade's airfoil faces away from the wind, rather than into it, as on an airplane propeller (see illustration, p. 70). When wind blows across the blade, lift is produced over the curved side, creating a force that begins to turn the rotor in the desired direction. A generator then converts the mechanical power of the rotating shaft into electricity, which is fed through underground lines to power substations. There, transformers step up the voltage to meet the utility's needs.

There are two styles of horizontal-axis machines: upwind and downwind. On upwind machines, the rotors are upwind of the tower. Appearing to face away from the wind, downwind machines have rotors downwind of the tower.

Upwind models most commonly come from one of several Danish manufacturers. Denmark, as a matter of policy, long ago rejected nuclear power and committed itself to wind as one of several energy alternatives. The Danish manufacturers primarily make turbines with fixed-pitch blades—blades whose angle is fixed. These turbines rely on an elaborate mechanism to stay pointed into the wind. On each tower, instruments for measuring wind direction and speed provide information to internal circuitry. A small motor then turns the turbine to face the wind. If varying winds cause the head to revolve around in the same direction twice, twisting the power cables that drop from the generator to the electrical switching equipment at ground level, the circuitry tells the machine to bring itself to a stop. Then the motor "unwinds" the turbine head before the rotor resumes operation.

Other intricate mechanisms protect these fixed-pitch turbines from potentially disabling strong winds, which can "overspeed" the rotor, making blade failure likely. Massive brakes normally release the blades only when winds are blowing within the desired range—between 10 and 60 mph for most machines—and only when the machine's systems and the power grid it feeds are operating normally.

Once the blades are set in motion, generators can create drag to limit blade speed. Centrifugal force above a certain level will also force movable blade tips on the rotors to change pitch and create drag that helps slow the rotation, even if the other rotor control systems fail.

The biggest user of downwind machines, U.S. Windpower, is also the world's largest wind turbine manufacturer. Most of its 3,600 machines, which it assembles at a plant in Livermore, California, operate at Altamont Pass, spreading across dozens of square miles on the grassy rolling hills. Each machine's blades are attached at a slight angle so that the rotor disk is slightly conical, rather than flat. This allows the turbine to weathercock with shifting winds.

Blade fatigue continues to challenge designers, but wind turbine productivity has steadily improved (opposite).

Mary Van de Ven

The larger the turbine, the greater the amount of energy it can collect. The rotors on this experimental Hawaiian giant span over 300 feet.

Mary Van de Ven

An elevator inside the turbine's massive tower transports crews up a dizzying 192 feet.

The machines can also vary the pitch of their blades—automatically adjusting their angle—as many airplane propellers do. By altering the amount of lift the blades produce, the machines are able to maintain a constant rate of rotation in different wind speeds. When winds are either too slow or too fast, the blades feather, or turn parallel to the wind, to stop lift.

On U.S. Windpower wind farms, microprocessors in each machine send status information to computers in one of two block-like buildings. In each building, dozens of screens display current information on windspeed, electricity production, and maintenance needs for some 1,800 individual machines. Operators in the buildings monitor the data, collect and analyze it, and dispatch repair crews.

The second major type of wind turbine, the vertical-axis machine, has roots in a 1929 design by Georges Jean Darrieus, a Frenchman who replaced a windmill's fabric sails with long, thin blades. Flowind, a Pleasanton, California company with machines at Altamont Pass and Tehachapi, has laced the hilltops with several hundred Darrieus-type windmills at each of its locations. Every windmill depends on two bowed aluminum blades attaching at the top and bottom of a vertical axis. When the wind blows they spin like eggbeaters, but *big* eggbeaters: the most common model stands 104 feet tall and 55 feet wide.

Because of their design, vertical-axis machines don't need to be turned into the wind. Like the wind turbines atop vents on buildings, they are always ready to spin, regardless of the direction in which the wind is blowing. Having the generators at ground level gives them another advantage: maintenance is simpler. But their long, bowed extruded-aluminum blades, weighing 2,000 pounds each, are subject to severe stresses.

Different as their styles are, all wind turbines share some common characteristics. They are more expensive than they look, costing $100,000 to $250,000 each, depending on size. And installation requires miles and miles of buried electrical and control cables running from each wind generator to collection substations, and then on to the utilities.

Finding sites for wind farms is no easy task. A good wind is the first requirement, of course, but the developer must be able to get heavy equipment to the site, install massive concrete foundations, have access to power lines relatively nearby, and be near a place where selling the power will offer an adequate return on the investment.

The 12-volume *Wind Atlas,* a government publication, gives wind measurements and maps for the whole United States. But wind energy consultants like AeroVironment do their serious prospecting by helicopter, looking for wind-deformed vegetation, wind erosion, or topographical features that might enhance wind flow. They then install towers at selected sites and measure the direction and speed of wind at various heights: an average annual wind speed of 12 mph is considered the minimum needed to build a wind farm. Such a study might take more than a year.

In the risky energy business, such expenditures of time, as well as the costs of purchasing and installing equipment, are all part of the gamble. As oil prices fluctuate, other energy sources gain and lose appeal. The future of the wind business is hard to predict, says Tom Gray of the American Wind Energy Association. "I have a sense that the full ingenuity of these wind farm developers is just being tested." ←

Berl Brechner

BLAST FROM THE PAST

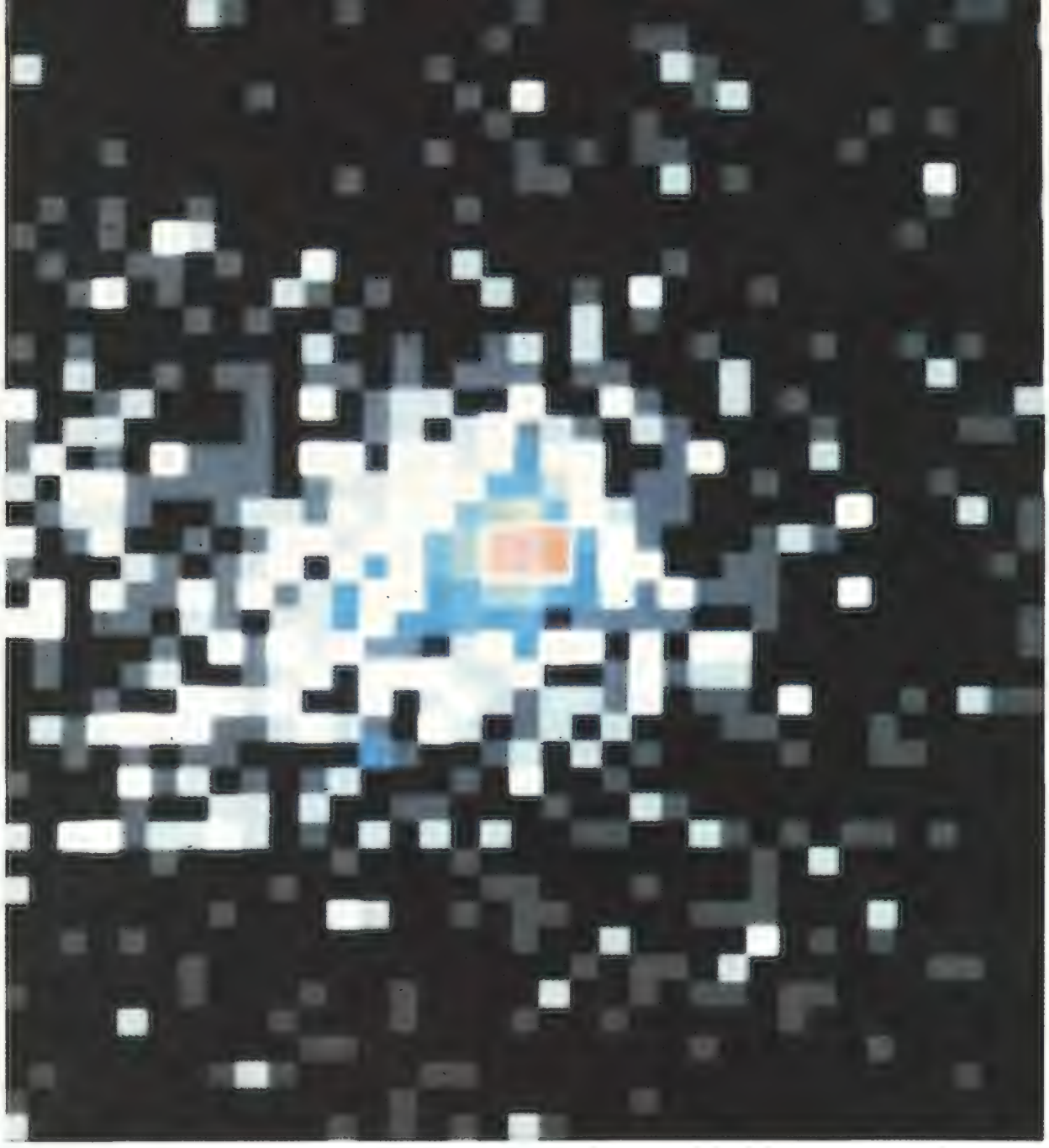
An aging satellite beams down the epitaph for a star.

by David DeVorkin

When the International Ultraviolet Explorer satellite was launched in January 1978, the light from the supernova that astronomers now call SN1987A was still 52 trillion miles from Earth. At the time of the launch, no one knew that a star had exploded about 160,000 years earlier in the Large Magellanic Cloud, a galactic companion to the Milky Way. During the next nine years, as the light from the supernova streamed toward Earth, the IUE earned its reputation as the most productive astronomical satellite ever built. No one would have guessed that its crowning contribution would come six years after it was supposed to have been retired.

The supernova's fingerprint was taken by focusing its light on a round, ultraviolet-sensitive surface. The IUE satellite's instruments first spread the light into a high-resolution spectrum, then cut it up into bands. Colors indicate intensity, decreasing from red to green, blue, white, gray, and black. Dark patches in the bands show wavelengths where light is being absorbed.


NASA



NASA

The IUE Fine Error Sensor captured the supernova in this computer portrait, a cluster of squares color-coded for brightness. The surrounding dimmer squares could be nearby stars or electronic noise.

The first supernova in almost four centuries bright enough to be seen with the naked eye, SN1987A was spotted by University of Toronto astronomer Ian Shelton on February 24, 1987. Shelton and the astounded astronomers at Las Campanas Observatory in the Chilean Andes sounded a worldwide alarm about the fierce new fire in the Large Magellanic Cloud. They tried to get word to Brian Marsden at the International Astronomical Union's Central Bureau for Astronomical Telegrams, a worldwide network for alerting astronomers that something new is in the sky. Unable to get through, they finally called their colleagues at the University of Toronto and later telexed Marsden, who notified the rest of the world. Astronomers lucky enough to be in the southern hemisphere, the area of Earth from which the Large Magellanic Cloud is best visible, turned their telescopes to the spectacular apparition. Astronomers in northern latitudes couldn't see a thing unless they had a satellite.

Unfortunately, U.S. astronomers were caught with their satellites down. "The giant projects were missing," bemoans supernova specialist Robert Kirshner of the Center for Astrophysics in Cambridge, Massachusetts. "Space Telescope was not in orbit, the AXAF [Advanced X-ray Astronomy Facility] hasn't been built, nor has the Gamma Ray Observatory. These would have been the obvious tools for studying this thing." A less obvious but nevertheless pretty handy tool was the IUE, a modest little orbiting observatory with an 18-inch telescope, two spectrographs, and real-time telemetry. The satellite has democratized ultraviolet astronomy, giving 1,600 astronomers in the United States and Europe the chance to observe. Among more notable discoveries with the IUE is the recent detection of sulfur in the nuclei of comets, which hints at their primordial nature.

The satellite's real-time response and almost complete command of the heavens have kept it booked solid for 24 hours a day since its launch in 1978, but, with considerable prescience, the IUE administrators had created a "target of opportunity" observation program to give viewing priority to astronomers specializing in surprises, like comets or supernovae.

Astronomers are hard to surprise. Since the 1930s, when Swiss astronomer Fritz Zwicky coined the term for these super-luminous objects that can be distinguished even in the nebulous light from distant galaxies, scientists have been expecting to get a closer look at a supernova. In the meantime, they have developed theories to explain why a star's life ends in so cataclysmic an explosion. Unlike a nova, a star that simply blows off portions of its outer shell and remains intact, a supernova marks the death of a star. One kind of explosion occurs in a supergiant star when atomic fusion, the furnace that generates the star's light and heat, stops producing the energy needed to counteract the gravitational pressure of the stellar mass. The star slams in on itself, and the resulting explosion demolishes it or leaves behind an unimaginably dense ash (see "Heavy Metal," p. 84).

Before SN1987A appeared, a handful of astronomers, supported by the National Science Foundation, had been

Susan Lapides

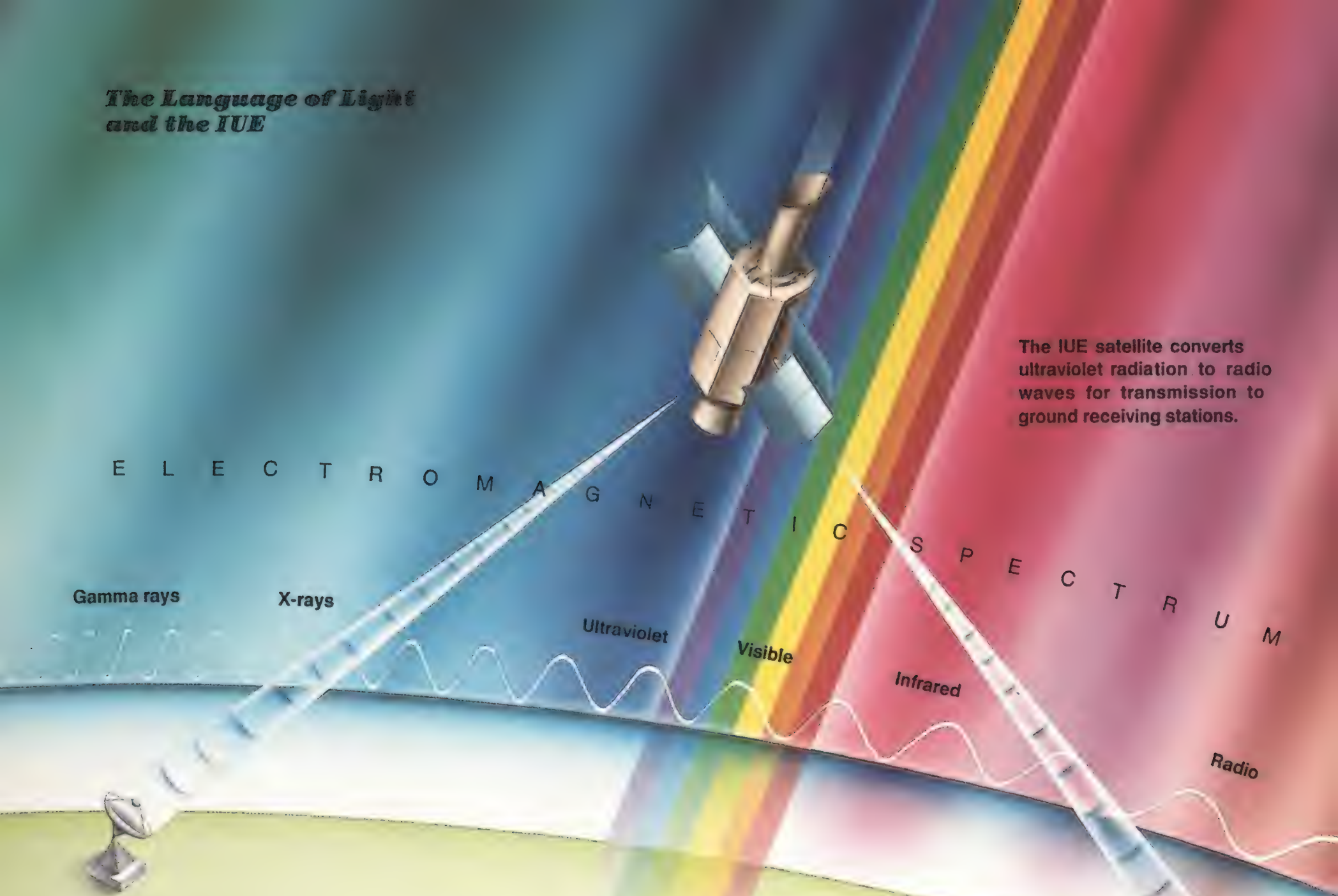
Supernova expert Robert Kirshner of the Center for Astrophysics continues a 140-year tradition of observing the sky, begun with the center's 1847 "great refractor," the first telescope used for photographic observations.

developing detailed theoretical models of supernova behavior. They calculated all the conditions that would turn a star into a supernova: age, size, color, brightness, mass, and composition. In short, they provided a complete scenario to enlighten observations, should the occasion arise.

Robert Kirshner was the astronomer with IUE priority when SN1987A became the "target of opportunity." Since last February, Kirshner has used supernova theory to interpret IUE observations of the ultraviolet radiation that does not penetrate Earth's atmosphere enough to be detected. This radiation must be studied by instruments on spacecraft.

"We knew what the questions were," Kirshner says. "The sustained support for the investigation of this line of work has been tremendously important. People have been thinking about

The Language of Light and the IUE



Earth-based telescopes can receive only visible light, some infrared radiation, and the middle frequencies of radio waves.

Light can tell many things about the star that sends it. In order to translate its message, astronomers have learned to spread light into a spectrum, the pattern of its constituent wavelengths, or levels of energy. The most familiar pattern is a rainbow spectrum, the side-by-side array of colors that appears when visible light is passed through a simple prism.

A far more intricate, and therefore informative, pattern is created by a spectrograph, a sophisticated device that spreads light out in all its detail and records the pattern that results. The pattern of light from a star is a continuum, like a rainbow, with a series of bright and dark lines. The lines indicate that light is being emitted or absorbed only at certain wavelengths.

The wavelengths of the lines—that is, their positions on the electromagnetic spectrum—identify the chemical elements in the star or the star's atmosphere. The position of each line is unique to a given element: a standard hydrogen line appears at 6563 angstroms, for example, a position in the red region of the visual spectrum. Strong or deep lines mean that an element is plentiful.

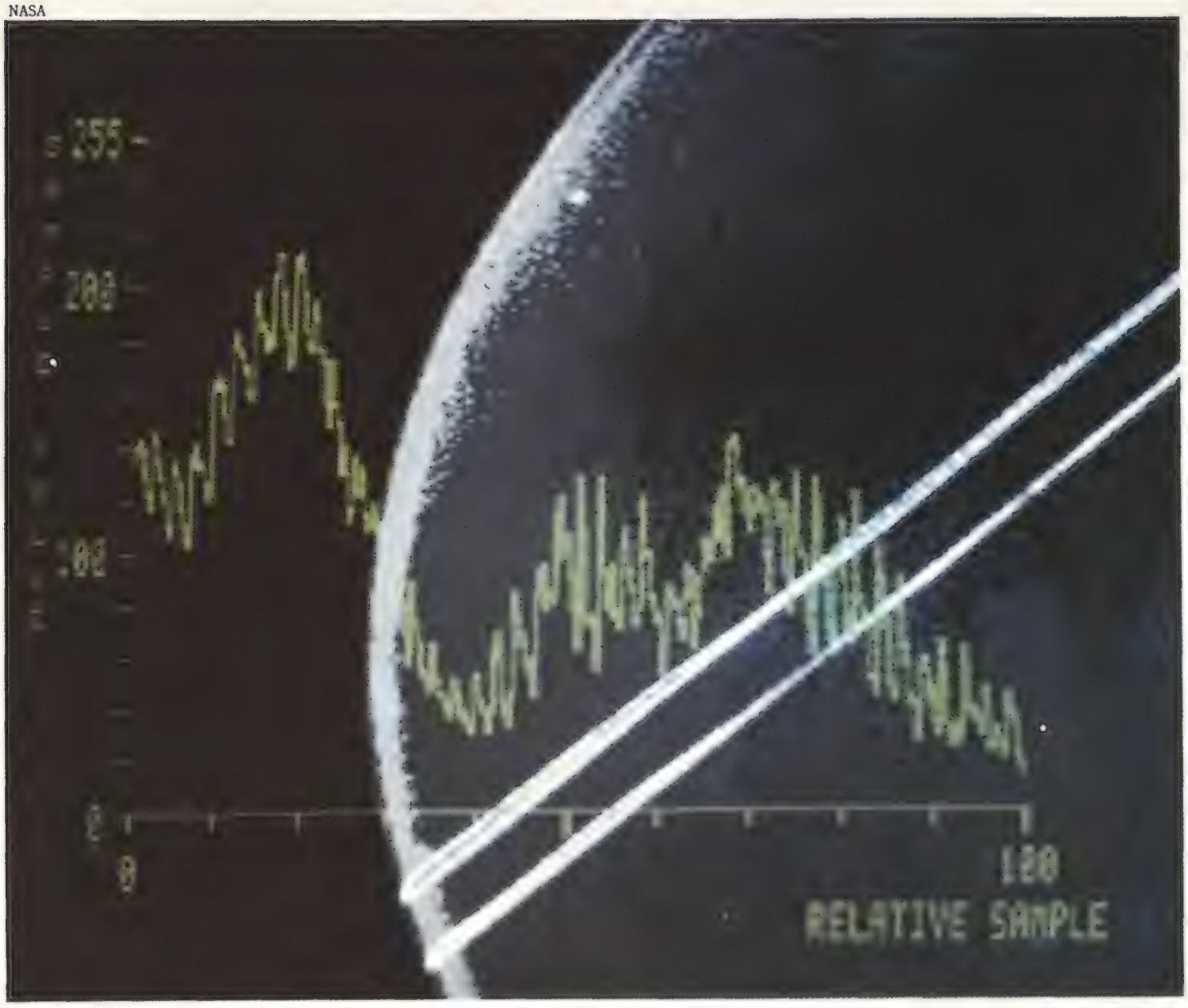
The lines of a spectrum also describe the state of the light source. If the lines are very wide and blurred, the gases are very turbulent or the element is extremely abundant.

Receiving and decoding the messages from the stars is complicated by the fact that only visible radiation and certain wavelengths in the infrared and radio ranges can reach Earth. Spectrographs must be carried above the atmosphere, therefore, to collect, process, and transmit the radiation that can't get through.

The International Ultraviolet Explorer's spectrographs are specially designed to process ultraviolet radiation. The satellite's 18-inch telescope gathers the radiation and feeds it to a spectrograph, which in turn sifts it and passes it on to electronic detectors. These convert ultraviolet photons to electrical signals, which are then transmitted to Earth. Dedicated ground tracking stations at Wallops Island, Virginia, and at the Villafranca ground station near Madrid, Spain, receive IUE transmissions and send them to engineering control centers. Two scientific centers, one at NASA's Goddard Space Flight Center in Greenbelt, Maryland, and the other near Madrid, have a time-sharing schedule that permits remote-control observations 24 hours a day.

The IUE has revolutionized ultraviolet astronomy by making space-based observing as fast and easy as using a ground-based telescope. Although it is not the first satellite to take an ultraviolet telescope into orbit, it is the first "real time" space observatory, capable of moving quickly and being adjusted without delay, just like an Earth observatory. But because it is 22,500 miles away, the IUE has a much larger view of the sky.

NASA



The peaks and valleys of the green tracing, plotting ultraviolet brightness versus wavelength, profile the emission and absorption levels in the topmost of two low-resolution spectra (diagonal lines). These spectra, produced from the light received by the detector's round surface, are less elaborated and more compressed than the fingerprint spectrum on pp. 76–77.

supernovae right along, so we were able to fit the data from 1987A into a framework of ideas."

Kirshner teamed up with George Sonneborn, a resident astronomer at IUE headquarters, the Goddard Space Flight Center in Greenbelt, Maryland. Together they provided the world with the most thorough record ever made of the ultraviolet light from a dying star. They were joined by astronomers at the Villafranca ground station, Goddard's counterpart near Madrid, Spain. The IUE, parked in geosynchronous orbit 22,500 miles above the Atlantic, is in contact with either Goddard or Madrid 24 hours a day.

At 10:30 a.m. on February 24, University of Toronto astronomer Nancy Evans, who had been scheduled to use the IUE that afternoon, called Goddard with the news of the supernova. The call came before Marsden's official alarm reached the IUE offices, and Sonneborn, the supervisor of the telescope operations staff, was faced with the first decision of many on that long day: whether to interrupt the guest observer of the moment, Dartmouth astronomer Gary Wegner, and the IUE operator, who was about to aim the satellite at the next object. Sonneborn had been fielding starlight with the IUE for four years and was as anxious as any outfielder would be when a once-in-a-lifetime high fly is heading for his glove. And he knew that time was precious. Ten hours had already passed since the night observers in Chile had seen the supernova.

But Sonneborn had to have more information. To observe a supernova with a telescope sitting 22,500 miles above their heads, the operators needed precise spatial coordinates and a fairly accurate estimate of how bright the object was in the ultraviolet. They also needed official confirmation from Brian Marsden at the International Astronomical Union clearinghouse.

"All we had was what Nancy read to us over the telephone," Sonneborn remembers. "Even if we maneuvered there immediately, then we would have to sit down and calculate probable exposure times. There was about a 40-second period there when we wondered, Should we go ahead and start [Wegner's] maneuver, or should we wait?"

Sonneborn saw no wisdom in waiting. He directed Wegner to go on to the next observation, and he used the time to work on brightness estimates and exposure times for the supernova. The decision lost an hour.

Luckily, Sonneborn had a place to start, having observed several novae and extragalactic supernovae with the IUE. He consulted the electronic database he had created for brightness estimates of galactic novae. From these he could extrapolate proper exposure times for the supernova. While he was making his calculations, an operation akin to setting, while blindfolded, the proper shutter speed on a camera, confirmation came of the reality and the location of the supernova. One hour before the end of Wegner's shift, they were ready.

Cerro Tololo Inter-American Observatory

Supernova 1987A blazed with the energy of 300 billion suns, outshining the vast Tarantula Nebula.

Sonneborn punched the computer command to slew the IUE to the coordinates he had been given and became the first person in the northern hemisphere to see the supernova. What he saw was an image of the star that the computer had constructed on the operator's console. The computer receives electronic information from special television cameras in the IUE and translates the electronic pulses into a picture.

But the images that would reveal the most information about the supernova were the spectra, patterns of bright and dark lines formed when the spectrographs spread the collected light into its component wavelengths (see "The Language of Light and the IUE," p. 80). The supernova was astonishingly bright; Sonneborn's first exposure was three times too long. But the spectra that he and his colleagues bagged during the first eight hours of observations, before the European station took over, constituted the first conclusive proof that the supernova was indeed in the Large Magellanic Cloud, not in front of it. The spectra showed dark lines, which result when light is being absorbed by interstellar matter between the star and the telescope. The pattern, composed of widely separated double lines, indicated two velocities: one component matched the profile of interstellar matter in the Milky Way; the other came from material in the Large Magellanic Cloud.

Meanwhile, patterns in visible-light spectra taken at Las Campanas confirmed the picture that the theorists had painted of a supernova. Dark absorption lines, shifted toward the blue end of the range, were all accompanied by bright emission lines. This pattern indicated a vast cloud of light-absorbing gas. The shift of the wide absorption lines toward blue meant that the cloud was expanding; the degree of the shift revealed its velocity. The cloud was growing in radius by at least 11,000 miles every second. Twenty-four hours later the change in the position of the spectral lines showed the expansion had slowed to 9,300 miles a second. But even at that rate, it would take the shell only 26 seconds to pass from the moon to Earth.

In the first hours after discovery, astronomers thought they had a classic supernova of the brightest and most powerful kind by the tail. The popular astronomy magazine *Sky & Telescope* whooped: "This is It! This is IT!"

The spectrum continued to change daily, necessitating constant readjustments in the instruments. Most of the changes matched theoretical predictions, but further IUE observations showed the ultraviolet radiation weakening by a factor of 1,000 within the first three days. This unpredicted dimming made Sonneborn and Kirshner wonder what "it" really was.

The decrease of ultraviolet light occurred while the visual-light curve was still increasing, as ground-based telescopes in Chile and Australia were madly reporting through Brian Marsden's telegrams. Everyone was trying to wrest every scrap of knowledge he could from old photographic plates and new electronic images. What kind of star blew up? Were there enriched heavy elements in the blast wave? How much mass was involved? And while Kirshner was still trying to account for the baffling ultraviolet dimness, Sonneborn found another puzzle.

On February 27, Sonneborn aimed the IUE at the supernova and stared at

Katherine Lambert

Spectrographs 22,500 miles above Earth are at George Sonneborn's fingertips at the IUE control center.

the high-resolution monitor on the control console. The monitor showed a spectrum that did not look like it came from a nice round object like a single star. "At first I thought we were seeing the actual ejecta," recalls Sonneborn, "but then two seconds later I realized that that is completely impossible .... That would have made it really close. We must still be seeing the supergiant, and so something else exploded ...."

The supergiant Sonneborn referred to was Sanduleak −69°202, a blue supergiant in the Large Magellanic Cloud. It had been identified on earlier photographs of the region, and its position made it the popular choice for the supernova progenitor. It also seemed to have a very faint companion close by. Sonneborn worried that the unusual structure of the spectrum meant that this companion still had company.

Kirshner's first impression was that the IUE was still showing Sanduleak and its companion and that the identity of the supernova's progenitor was still eluding them. He kept repeating to himself, "Two before, two after, none gone," and that was the riddle he presented at the meetings that NASA called at Goddard in the first week to organize efforts to study the supernova.

Astronomers Nolan Walborn and Barry Lasker provided the means to solve the riddle. Using sophisticated image processing techniques and the computers at the Space Telescope Science Institute in Baltimore, Maryland, they proved the existence of a very faint *second* companion.

"Once we realized that there were three stars there," Sonneborn recalls, "we had to go back and look at the IUE spectra very carefully" to find the one that had exploded.

Kirshner and Sonneborn turned to Bruce Altner of the Applied Research Corporation, who was also working at Goddard on the IUE and was especially familiar with how to use the IUE in crowded star fields. He had written just what they needed: a computer code to sort out overlapping stellar spectra in globular clusters. "How would you like fame and glory?" Kirshner asked him.

With Altner's help, Kirshner and Sonneborn measured the apparent separations of the unresolved parallel spectra on different days over several weeks' time. The separations changed as the orientation of the IUE changed, and this small difference allowed the scientists to deduce what the actual separations were.

Heavy Metal

According to supernova theory, stars spend most of their lives happily converting hydrogen into helium through thermonuclear processes. Eventually, they will deplete the hydrogen available for fusion. In stars far more massive than the sun, those that will undergo violent death as supernovae, the depletion of hydrogen will set off a series of other fusion reactions. The structure of the massive star will change, causing its core to heat until conditions are right for the fusion of helium into carbon, nitrogen, and oxygen. As helium is exhausted, heavier and heavier elements will fuse until the core becomes enriched in iron.

Each cycle of fusion continues to occur in the shells enclosing the iron-enriched core. The fusion reactions create energy, counteracting the gravitational forces that hold the star together and producing starlight as a by-product. But iron fusion, unlike the previous reactions, drains energy and creates a crisis: the star no longer has the energy to resist its own gravitational pressure.

When fusion in the Earth-sized iron-enriched core turns off, the core collapses within a fraction of a second. Electrons ram into protons, producing a violently collapsed sea of neutrons, which in turn releases a swarm of neutrino energy. Matter left in the outer layers of the star falls inward, hits the iron wall of the neutron core (now collapsed to a diameter of six miles), and rebounds with an enormous acoustic shock wave outward. Secondary shocks form between the outgoing acoustic wave and the incoming matter, heating the region to over five billion degrees and causing explosive nucleosynthetic processes that form heavy elements in the expanding blast wave.

These heavy elements all mix in the turbulence of the instant and are thrown out into interstellar space. In the following months, years, and millennia, the enriched material carried in the shock wave races through space, heating clouds of gas and dust and, some astronomers think, stimulating the formation of new stars and planets enriched with the heavy elements produced in the cores of their celestial forebears.

It took them a month to get sufficient position data to decide that they were still seeing stars 2 and 3; star 1 (Sanduleak −69°202) was gone, and in its place was the supernova.

Kirshner recalls that after the identification was certain, his National Science Foundation program officer, the fellow who coordinates funding for astronomy, sent him a can of red herring. "He said he wanted to send a can of crow but couldn't find any in local grocery stores," Kirshner says.

The puzzling dimness of the light, compounded by the even more puzzling identification of the victim, led scientists to revise their theories of supernova origins and re-examine the phenomenon called stellar wind. The Sanduleak object was an intensely bright blue giant star before it blew up, not a red supergiant, the type that, according to theorists, exhibits supernova tendencies. Its blue color explained the dimness in the ultraviolet light curve. Blue supergiants are far more compact than bloated red supergiants, and as a result a far greater fraction of the energy of the explosion is expended in blasting away the outer layers of the star. Less energy is left to be dispersed as light.

Further observations with the IUE suggested how a blue star might wind up on the supernova track. With the hot expanding shell acting as a magnificent lightbulb illuminating the interstellar medium around it, the IUE spectrographs revealed a region of space enriched with nitrogen, which must have been expelled from the progenitor star in a stellar wind. From the amount of material found in the region of the Sanduleak star, astronomers concluded that there had to have been a prodigious stellar wind in millennia past. The vastness of the wind suggests that the Sanduleak object may indeed have been a red supergiant because the red variety lose more mass in stellar winds than blue supergiants. The star could have changed color in the not-too-distant past, maybe as recently as 100,000 years before it exploded.

All sorts of stellar products and processes are still being revealed by SN1987A in all ranges of the electromagnetic spectrum. In addition to the IUE, virtually every major optical and radio telescope in the southern hemisphere has at one time been put into service. In the months following the blast, the Japanese Ginga X-ray satellite and a huge battery of X-ray instruments attached to the Soviet Mir space station have been monitoring the progress of the blast wave. NASA's Kuiper Airborne Observatory has flown several times from New Zealand looking for the infrared signature of the explosion, and groups of NASA X-ray and gamma-ray balloon and sounding rocket experimenters have flown exotic detectors from Australia.

The first burst of energy that reached Earth even before visible light has already engendered the new science of neutrino astronomy. Neutrinos are unimaginably elusive particles—at most 0.00004 the mass of an electron—that are created in rapid fusion processes, such as those that take place in the collapse of a star's core. A silent wave of 10^{58} neutrinos from the supernova bombarded Earth on February 23, 1987. Most passed right through, but 19 were intercepted in special detecting pools of ultrapure water deep underground. Astrophysicists are now extracting information from the 19 interceptions to explain the dynamics of this supernova and to construct theories in anticipation of the next one.

Astronomers expect the gases ejected by the supernova to overtake the material from the stellar wind in about 10 years. No one expects the IUE to be around for the fireworks, but then, its original life expectancy was only three years and it has lasted for 10, transmitting more than 65,000 spectra in that time and still collecting data. Even astronomers are surprised. →

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My Friend, G.M.

To pilots who flew his monoplanes in the 1920s and '30s, Giuseppe M. Bellanca was a genius. To me, he was that and more.

by Elinor Smith

Courtesy Elinor Smith

From my father's Waco 9, I could see a lone figure on the sand dune below gazing up at us. I had no idea who he was and idly wondered why anyone would wear a business suit, straw hat, and black shoes to the beach. But just then my father made one of his uniquely creative landings, undershooting the landing strip, clipping his wheels in Jamaica Bay, and cartwheeling the little biplane onto its back.

My brother Joe and I found ourselves hanging upside down by our seat belts when Business Suit and Black Shoes raced up. He showed us how to release ourselves and roll out onto the top wing. Meanwhile, Father, in the rear cockpit, had released his belt during the excitement and fallen out on his head, and now the air was blue with a barrage of words we'd never heard before.

Business Suit poked and prodded to make sure nobody had broken anything, then inspected the wrecked airplane. He seemed to know a lot about it, for which Father was most grateful; an airplane's innards, in which Father had at best a cursory interest, had always been a complete mystery to him. Our new friend busily made slits in the linen with his penknife, noting cracked longerons, bent struts, broken ribs and spars. Only the two lower wings, their leading edges still intact, were salvageable.

The goal of this fateful outing had been a Sunday picnic on the sandbar site of Red and Martin Devereaux's passenger carrying operation. They'd set up the business on a beach strip that paralleled Cross Bay Boulevard, a heavily trafficked highway connecting the Rockaways to Brooklyn. Red Devereaux, a close friend of Father's, was teaching Father and me the more advanced flying techniques. He would teach whoever was available, and since Father's business commitments often kept him from the airfield during the day, I got the best of this arrangement.

In 1927, a 15-year-old girl flying an airplane by herself was enough of an oddity to arouse skepticism. I found out later that the straw-hatted stranger was already aware of me. In fact, without our knowledge, Red had arranged for him to be on the beach that day to see me for himself.

When the matter of the picnic had arisen, Red told Father to be sure I was at the controls. The Waco had straight-axle landing gear and no brakes, so sandy landings required a spe-

Bellanca (opposite) had a lifelong fascination with flight; "I can see air," he declared as a boy.

In 1929 the author posed with the Bellanca CH she would soon use on a record-breaking endurance flight.

NASM

Courtesy Elinor Smith

Always favoring monoplanes, Bellanca built this parasol-wing craft in 1911, then taught himself to fly.

cific technique, one Red had recently taught me.

"Sand—wet or dry—is tricky, Tom, and you haven't had the chance to learn to set down in it yet," Red had cautioned my father.

Well, you couldn't tell my father he didn't know how to do something, even when he didn't. So on the Sunday of the picnic I was not surprised to find myself in charge of the hard-boiled eggs and the pickles instead of the Waco 9.

Red was so relieved when he found out I had not been at the controls during this little disaster that he forgot to be mad at Father for disobeying his instructions. Instead, he put me to work flying passengers in one of his own ships. A huge crowd had gathered to gawk at the cracked-up airplane, so business was brisk.

The cheerful mien of the hatted stranger—he said his name was Cheam—did much to keep Father's spirits up. Cheam too, it turned out, had been around airplanes for years and had yet to fly one properly—for Father, a true aficionado indeed. Speaking softly and with an Italian accent, Cheam told us of his experiences during operation of a flying school on the old Mineola plain on Long Island, prior to the establishment of Curtiss Field. He explained how he'd taught himself to fly his homebuilt airplane by taxiing it around and then hopping into the air for longer periods each day.

Just before he left, the slight, dark-haired man sprinted over to the cleared-off flight area where I was taxiing and motioned me to stop. Climbing up on the airplane's wingstep, he shoved a card into my hand, saying something that sounded like "You get in touch with me when you are ready—yes?" Having no idea what on earth he was talking about, I smiled, tucked the card into my jacket pocket, and promptly forgot about it.

A week or so later, Mother found the card as she was going through my pockets before sending the jacket to the cleaners. She came into the living room holding it out to Father.

"Tom, you never said that your Italian friend was Giuseppe M. Bellanca."

Father reached for the card and stared at it unbelievingly. "Good God!" he exclaimed. "No wonder he knew so much about aeroplanes. And he thought all along that we knew who

Courtesy Elinor Smith

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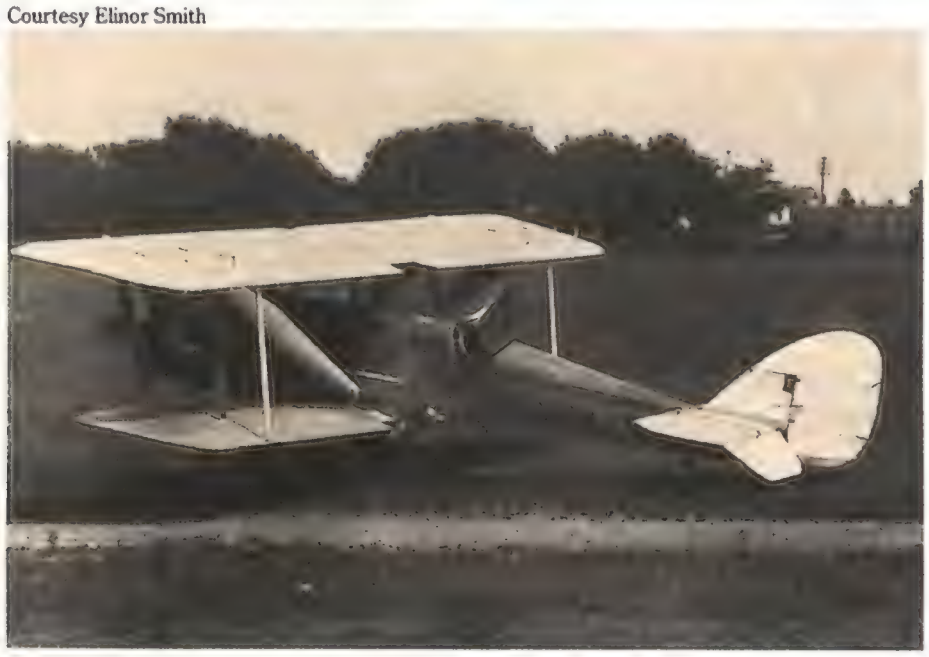

The improved DH-4: Bellanca's perfectionism helped to refine his designs but made it difficult to meet deadlines.

The Bellanca C.E. of 1919, which excelled as a stunt plane and trainer, brought the designer wider recognition.

he was. And of course we *should* have known, but I've never seen a picture of him—and every time he was on the field, I've been somewhere else. I thought he said his name was Cheam. He must have been telling us it was G.M.—that's what the pilots call him . . . ."

If the face was not familiar, the name certainly was. Bellanca and his airplanes were well respected by pilots of the day. His monoplanes were widely considered the best performers in their class. Just a few months earlier, Charles Lindbergh had come to Bellanca looking for an airplane to fly across the Atlantic. Difficulties in dealing with Bellanca's backer eventually drove Lindbergh to Ryan Airlines instead; Bellanca himself soon broke away to reorganize his company. Less than a month after Lindbergh's successful flight, the Bellanca-designed *Columbia* crossed the Atlantic and exceeded Lindbergh's distance record by flying beyond Berlin. After that, Bellanca monoplanes figured in many ocean crossings and other record-setting flights in the 1920s and '30s.

Giuseppe Mario Bellanca arrived in America in 1911 with a degree in engineering from the Technical Institute of Milan. Offsetting this expertise was his inability to speak a word of English, a handicap he overcame in a matter of weeks.

"Actually, I had a very pleasant time," he once told me. "I went to the nickelodeons every afternoon after I'd gone through the daily papers. At the movies the subtitles were in English and I could easily relate the actions to the words. And when I was stumped in my reading August would translate."

The Bellanca family had always been supportive of one another, and older brother August did a great deal more than just translate for Giuseppe. In fact, it was due to August that Giuseppe was in America at all. Convinced that G.M. would make his way in the United States much faster than he would in Italy, August had brought him over and installed him in a rented brownstone in Brooklyn.

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The most famous Bellanca, the Columbia, *crossed the Atlantic only days after the* Spirit of St. Louis.

When the Bellanca Aeroplane Company was formed the next year, August turned to the local community for financial backing, and an owner of an Italian restaurant, along with several of its cooks and waiters, was among its chief investors. The lawyer who drew up the papers—Fiorello La Guardia—was a friend of August's and later became a flying student of G.M.'s when the company built its first airplane. Their first flight together was a memorable one.

As G.M. later recounted the story, the flight had ended short of the field when the airplane came to rest in a treetop. In the silence that followed their grinding crash, G.M. agonized over asking if La Guardia had been injured. Before he could open his mouth, the future New York mayor turned to him and asked how you stopped an airplane if you couldn't find a tree.

In 1912, when Bellanca opened his flying school, the sport was largely self-taught. "As a skill," G.M. explained, "no one knew too much about it. It was simply a matter of trial and error . . . but it was very hard on the aeroplanes!" G.M. soon found that after mastering flying himself, his greatest challenge was to keep ahead of his students. "That wasn't so easy as I seemed only to attract very smart students," he said. But the school prospered and in a couple of years he was able to get back to his first love: designing.

If only his talents as a designer had been recognized and appropriately rewarded—but his own nature thwarted him. He stubbornly refused to compromise safety performance to meet the demands of contractual dates of completion, and it cost him a lucrative contract with the U.S. Postal Service.

In 1923 the postal service was casting about for a way to incorporate night flying into its service. It used de Havilland biplanes: heavy, underpowered craft that handled like trucks and had a hot landing speed of 60 mph—without brakes, remember. Although the DH-4s were reputed to have a cruise speed of 100 mph, some of their pilots sourly reported that this could be attained only downwind in a dive. And their top speed at best was a lumbering 115 mph.

G.M. designed a set of wings for the airplane, buttressed by the famous Bellanca wide struts, that created lift of their own. His modifications boosted the DH-4's cruising speed to 113 mph and its top speed to 130 mph, and cut its landing speed to 40 mph in the bargain. The pilots who flew the first models were delighted, but because Bellanca refused to part with the design until he was completely satisfied with it, he was eight weeks late with the order and lost the contract. Only four of the modified de Havillands were built, and another builder with a cheaper but less effective wing received the award. From that day forth all G.M.'s efforts were directed toward the goal of taking charge of his own production schedules. It took him about five more years to achieve it.

Bellanca never walled himself off in a self-designed ivory tower, as some of his contemporaries had. His mind was always open to argument or suggestion. When I finally got up the nerve to call Bellanca—two years after we first met—he was quick to support my career by lending me his latest, specially outfitted models for record attempts and demonstration flights. He was the only manufacturer I ever worked for who never doubted that a qualified female should fly anything anywhere.

On the other hand, from the time in 1929 when I first landed at the Bellanca Company headquarters at New Castle, Delaware, for what turned out to be a successful assault on the world's solo endurance record, word went out that as I asked for no quarter I wasn't to be given any. That I was only 17 years old was immaterial. The airplane he offered me for this flight, a Bellanca CH with a 46-foot wingspan, was the biggest I'd flown yet.

He explained to me later: "I never had any doubt about your skill, and I was sure the favorable publicity resulting from a girl your age flying a ship this size would benefit all of us. Expecting mature judgment was a risky business, but I believed that if your mettle was tested and you won their respect, your reputation was assured. Time proved me right."

Thank goodness I didn't know how he felt at the time! To

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The Columbia *survived an awkward landing in Germany and went back across the Atlantic, the first to do so.*

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Altitude and endurance records set in Bellanca airplanes earned teenage Elinor the title Best Woman Pilot in the U.S.

this day I can't believe my good fortune to have been included in the roster of Bellanca pilots, which boasted George Haldeman, Clarence Chamberlin, Roger Williams, and Shirley Short. Not that my presence didn't invite criticism.

No female had ever managed a cabin ship of the size, weight, and horsepower of G.M.'s CH, Pacemaker, and Skyrocket monoplanes. On top of that I was still too young to apply for a transport license or to be considered for insurance, even by Lloyd's of London.

But his belief in me persuaded the du Pont board of directors, then the Bellanca Company's main backers, not to sell the CH I was testing for my endurance flight to a rival for spot cash. G.M. did the same thing for Haldeman and Chamberlin in similar circumstances. Is it any wonder that we exulted in his victories and mourned his defeats?

Of course he still encountered setbacks from time to time. Promised contracts sometimes didn't materialize, some airplanes took longer to produce than they should have, preparations for transatlantic flights dragged on and on. But G.M. never lost his cool. He smiled through his disappointments and encouraged the people around him.

Nothing battered him emotionally as much as the death of Shirley Short, a good friend and respected pilot. Short flew for the *Chicago Daily News* and persuaded the paper to purchase a custom-designed Bellanca. The order was quite a coup for G.M., and optimism ran high when the ship rolled out on the flight line. It ran even higher after the first tests. But during a later flight a catastrophic structural failure caused the ship to disintegrate, killing Short and two crewmen. A broken man, G.M. went into seclusion. We all worried and wondered how he could recover from this blow. The answer was—slowly.

He couldn't talk about Short for months. There was no laughter in him, and the first streaks of white appeared in his jet-black hair. But withdrawal was a luxury he could ill afford—the factory had to keep right on filling prior orders and the payroll had to be met. Work was his solace, and as he threw himself into it, we realized that we were watching grace under pressure.

It has been said that the marks of genius are the ability to endure tedium and a flair for the application of the seat of the pants to a chair. But the picture of a toiling drudge doggedly pursuing his goal to the exclusion of all other interests just didn't apply to G.M. He would work around the clock in times of crisis, but most of the time, moderation was his credo.

I doubt if his weight varied more than 10 pounds from a norm of 140 during his whole adult life. Dorothy Bellanca was a gourmet cook, and only a man of iron will could have resisted her meals. G.M. ate small portions of everything, and dinner

invariably closed with cheese and fruit, which he carefully sectioned with a silver knife.

Delicious as these dinners were, good talk was always the star attraction of the evening. G.M. was a delightful raconteur, but he was also a wonderful listener and made sure his guests had the floor, for when in his home you were a guest and were treated accordingly.

Having his friendship didn't affect your status on the field, though. Any serious infraction of the rules would bring on a scene that left you trembling. The little man would grow ten feet tall before your eyes, and you'd know just who the boss was and why. The tornado usually blew itself out in short order, but the sudden storms did keep you on your toes.

I have often been asked why, in view of his enormous talents and accomplishments, G.M.'s name has faded with time. His humility may be the reason for his relative obscurity today. He never did anything that might openly encourage the kind of national adulation some of his contemporaries enjoyed. He rarely gave interviews and he tended to downplay his achievements. As Clarence Chamberlin observed, "Unlike many designers, his estimates usually were conservative about what his ships would do, rather than over-optimistic."

When he did receive publicity, he didn't think he deserved it. "To have been welcomed by America was surely enough," he told me during one of our last meetings. "I could never have had this kind of success if I'd stayed in Italy. Realize, I've had a lifetime of doing what I thoroughly enjoy. I have a lovely wife, a handsome and gifted son, a beautiful home, and enough money to enjoy life. What more could I ask?" Knowing how hard he worked to achieve all he did, I found his humility hard to understand.

That conversation took place in 1960, shortly before his death at age 74. We sat and talked on the wide verandah of Shorewood Gardens, his magnificent estate overlooking Maryland's Sassafras River. Before us, rolling waves of velvety lawn ran gracefully to the river, where Bellanca's son August was gliding around in his new sailboat, showing it off to my daughters and son. This was a far cry from the heat, humidity, clanging, and banging of the New Castle factory some 30 years before.

Then the famous Bellanca chuckle surfaced once more. "And do you know the very best part?" he continued. "I don't have to worry about that Friday night payroll anymore!"

The brown eyes sparkled and in my mind's eye, his hair darkened from white to black as I giggled, just as I had when I was a teenager and he was the Boss. ⊣

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Bellanca found fame, American-style, at the height of his career, but more lasting recognition eluded him.

Take-Off

NASM

Anne Morrow Lindbergh's flight to China gave her a new window on the world.

In North to the Orient, *Anne Morrow Lindbergh describes the Washington-to-China flight she and her husband Charles made in 1931. Charles flew their float-equipped Lockheed Sirius, and Anne—after a cram course in radio operation—handled all communications. Charles described their voyage as a vacation, with "no start or finish, no diplomatic or commercial significance, and no records to be sought." Even so, they were the first to fly a northern route from North America to Asia, traversing Canada, then crossing the Bering Sea en route to Japan and Nanking, China. The voyage ended in early October when the Sirius, while being lowered into the Yangtze River from a British aircraft carrier, capsized and suffered wing damage.*

The Lockheed was back in commission by 1933, when the couple set off on a survey of transatlantic routes for Pan American Airways. The Sirius is now on display in the National Air and Space Museum.

In this chapter, Lindbergh describes her first attempt at airborne communications during the flight from the couple's home field in Long Island to Washington, D.C.

The twenty-seventh of July, 1931, was clear and hot. The heat of a whole summer was condensed dripping into that afternoon. A small crowd of people pressed tightly against the gates to the long ramp at College Point, Long Island. As we drove in I saw many familiar faces between movietone trucks and cameras. We had all spent sweltering days together on that wooden ramp, watching trial flights and the installation of equipment. Now the preparation was over, we were ready to go. I suppose they were as relieved as we. Friends came up to say goodby. "We all hope you are going to get through it all right," with voices and expressions that said, "But we don't think you've got much chance."

Picking up our baggage, we hurried into the shade of the factory office. A dark heavy heat hung over everything. Men in shirt sleeves ran in and out. We could hear reporters telephoning, "Just arrived in brown auto—now packing up the plane." I turned around; little boys were looking in the window at me and giggling. I mopped my face and counted my radio pads and pencils. A reporter poked his head in the door. "Can't you even say you think it is an especially dangerous trip, Mrs. Lindbergh?" he asked.

I laughed, "I'm sorry, I really haven't anything to say." (After all we want to go. What good does it do to talk about the danger? "What navigation is there voyde of perill?" . . . "What navigation—")

"But, Mrs. Lindbergh, we would like to get some impressions from you. What is it you dread most? What—" A kind friend repeated that I did not want to talk. It was too hot to talk, anyway. It was too hot to sit down. I leaned against the shiny cool-looking surface of a desk.

As I walked out of the building two women ran up to me.

"Oh, Mrs. Lindbergh," said one, "the women of America are so anxious to know about your clothes."

"And I," said the other, "want to write a little article about your housekeeping in the ship. Where do you put the lunch boxes?"

I felt depressed, as I generally do when women reporters ask me conventionally feminine questions. I feel as they must feel when they are given those questions to ask. I feel slightly insulted. Over in the corner my husband is being asked vital masculine questions, clean-cut steely technicalities or broad abstractions. But I am asked about clothes and lunch boxes. Still, if I were asked about steely technicalities or broad abstractions, I would not be able to answer, so perhaps I do not deserve anything better.

"No," I said. "I'm sorry, but I really haven't anything to say." (What could I say that would have any significance? All the important questions about the trip will be answered by my husband.)

"But you must not disappoint all the people who are so anxious to hear about you. You know, the American Public—"

(—will be disappointed if they don't know where I put the lunch boxes! You aren't going to ask me to believe that, I thought.)

"I'm sorry, I'm very sorry."

I turned to look at the plane. Perched on top of the big pontoons, it seemed small and dainty. They were rolling it down the pier. I thought of all the emergency equipment for North and South, land and water, all parts of the world, packed into that little space. I thought of the two of us, ready to go in it anywhere, and I had a sense of our self-contained insularity. Islands feel like this, I am sure, and walled cities, and sometimes men.

It was ready now; we could get in. "No, thank you, I don't need a ladder to climb up." A mechanic was just clambering out of my cockpit. I had a moment to wait and watch the crowd. A radio announcer was speaking into his microphone. "Mrs. Lindbergh," he started smoothly, with a glance at me, "is wearing a leather flying helmet and leather coat, and high leather flying boots."

"Why!" I thought blankly, looking down at a costume which did not correspond at all to his description. What nonsense! It was much too hot to wear leather. The sun beat down on my bare head and sticky cotton blouse; the hot planks of the pier burned through my thin rubber sneakers. What made him say that, I wondered. Oh, of course, it isn't the conventional flying costume. They have to say that I am dressed in leather. I see, you needn't bother to tell me again, I thought, looking at the announcer. I know, "The Great Radio Public must not be disappointed!"

The spray sluiced over the windshield as we started to take off—faster now—we were up on the step—we were trying to get off the water. I held my breath after each pounding spank as the pontoons skipped along from wave to wave. Weighed down with its heavy test load of fuel, the plane felt clumsy, like a duck with clipped wings. It met the coming wave quivering after each effort to rise. Now the spanks were closer together—quick, sharp jolts. I put my hand on the receiving set. It was shaking violently. Suddenly all vibration smoothed out. Effortlessly we rose; we were off; a long curve upward. The squat ferryboats below plowed across our wake, and great flat barges carrying rectangular mounds of different colored earth like spools of gold and tawny silk. I found the little black mass of people on the pier where we had been. Small and insignificant it looked, now I could see the whole life of the river: many piers and crowded ferryboats, ships and roofs and fields and barges,

When the Lindberghs flight-tested the Sirius over Los Angeles in the winter of 1929-30, Anne suggested the addition of the twin canopy.

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dredges and smokestacks and the towers of New York. We looked insignificant, also, and small to them, I knew, now that our bulk on the end of the pier no longer blocked the horizon. It had become simply a boat in the river of many boats; then a plane in the sky with other planes; now, only a speck against the blue, mistaken easily for a gull.

The photographer's ship banked under us and vanished. Our flight had begun. We were on our way to Washington for our final clearances and passports. I must start working on the radio. WOA at North Beach was waiting for my first message. "First see that the correct coils are in place." I knew the directions by heart. Slowly I let down the door which opened the transmitting set, and took out the two coils which were there. MO was printed on the back of one; PA, on the other. *Master Oscillator* and *Power Amplifier* —I knew those names anyway. They were such nice satisfactory names, one always jingling along rhythmically after the other—*Master Oscillator* (pause) *Power Amplifier.* They seem to belong inevitably together like Tweedledum and Tweedledee or Arabella and Araminta, and to complement each other like question and answer. Master Oscillator? Power Amplifier. I held them in my lap, as there was no other place to put them. They were both marked 5615 KC. That was not the right frequency. I was planning to send on 3130 kilocycles, therefore I must find the 3130 coils in the coil box at my feet. Feeling blindly, I took out two at random. (Later I could pick the correct coils by feeling them, as, for example, 500 had the most turns of fine wire.) They turned out to be 500 KC. These also went on my lap. Four more came out. One of the coils fell down and started rolling back into the dark unknowns of the fuselage. I stretched after it and picked up 3130. When I finally had the 3130's plugged in, I started trying to put the other coils back in the box. It was like trying to fit a lamp's plug into a socket in the dark. First I pushed them down with calm assurance. They would not slip in. Then I carelessly tried to jiggle them in, then scraped them along the whole box, trying to find the holes. I became very hot. Suppose I could not get them in? Would I have to hold them all the way to Washington? What would my instructor say—and all the newspapers! "Mrs. Lindbergh did not do any radio sending because she could not fit the coils into their places."

Power Amplifier—Master Oscillator—I looked at them side by side and suddenly noticed the plugs were placed differently. Power Amplifiers fitted into one side of the box; Master Oscillators, into the other side. (Arabella had a blue hair ribbon, Araminta had a pink hair ribbon, in the nursery tale. I remembered now.) How simple.

"Next unwind the antenna to the proper resonance point." (Approximately forty-eight reel turns for 3130 KC, my direction book read.) I counted forty-eight very carefully. I didn't trust myself to find the correct resonance point by experimentation. Then I practiced my message without turning the switch on the keyboard. The message had been written half an hour earlier, before my adventures with the coils. It read, "Now passing Newark Airport." I would have to change that to, "Nearing Philadelphia." I turned on the switch and called three times to WOA. A buzzing silence followed. Again. No results. I repeated frequently. Something must be wrong. Something quite simple; probably there was a main switch off. I hunted around and found another switch on the dynamotor, and turned it on. I tried to call again. Same result. I reeled the antenna in and out to be sure I had counted the turns correctly. The bulbs were burning in both sets. I remembered something about a knife-switch in the transmitter. "Should be closed when in the air to shunt out a resistance"—whatever that meant. I opened the transmitter and reached for the knife switch—something hit me in the chest! A shock. I remembered now—400 volts. My husband handed back a canteen of water and a note saying that there must be a "short" somewhere, and telling me to take out the fuses.

"I would if I knew what a fuse looked like."

He showed me a spare one. I took out the fuses and sat subdued for the rest of the flight. Someone had once told me that I was incredibly stupid in mechanical things. Everyone would say it was because I was a woman. Perhaps it was. If I were a failure at radio there would be plenty of time to think about lunch boxes and clothes.

"Don't look so gloomy," read the next note. "Probably due to a short circuit when they installed the compass light—get it fixed at North Beach on our way to Maine. Anyway, the radio isn't important from New York to Washington. Very good weather, too."

I looked out. We were circling over the Potomac River and our anchorage, the little inlet behind Bolling Field. Calm waters mirrored the breathless willows. Our first day's flying was over.

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"There Has Been a Crash in Denver"

It was snowing in Denver on that Sunday afternoon in mid-November, the first heavy snow of winter 1987. At the Continental ticket counter at Omaha's Eppley Airport, we were busy checking in passengers for the 11 a.m. flight to Denver after canceling the 7:20 departure. Barring air traffic delays, flight 1751 would depart on time.

The woman next in line started to hand me her ticket, then hesitated. "What's the weather like in Denver?" I called up the Denver report on my computer and explained to her that though it was snowing there her flight would leave on time.

"I've almost been killed three times in airplanes," she said. "I don't want to go today." I offered to list her as a standby on a later flight, but because she had a non-refundable ticket that was the best I could do. "Let me talk to my family," she said.

On her third trip to the counter to check the weather, she asked, "Are you sure it will be safe to go?" I patiently explained that airplanes were safely flying in and out of Stapleton airport, most close to their schedules. However, if the captain didn't think it safe, he wouldn't go. She finally decided to take the flight.

As I checked her in I felt a twinge of guilt for talking her into something she clearly didn't want to do. But no airline captain would jeopardize the safety of his passengers to meet a schedule. Besides, Federal Aviation Administration regulations clearly define minimum operational standards for airports, aircraft, and their crews. If the weather drops below minimums, the flight operations people will delay or cancel the flight.

The woman took the escalator to the gate. Behind her were a father and son going home to Boise, Idaho. I had chatted with them as I checked their luggage through, writing the number of their connecting flight, 1713, on the Continental baggage tags. Half an hour later 1751 took off, climbed through the overcast, and turned for Denver.

By 3 p.m. the storm had intensified and was causing major delays. Our 1:20 departure had been canceled, forcing us to rebook passengers on later flights and on other airlines. Customers stood a dozen deep at my counter as I searched the computer for alternative routing and waited for an open phone line to confirm reservations on other airlines.

It was sometime after three when an agent asked to use my terminal. I gave her a puzzled look; there was another a few feet down the counter. "It's important," she insisted. I stepped aside and watched her type a message meant only for me. "There has been a crash in Denver." Her eyes told me the rest: it was one of our airplanes.

I felt a surge of panic as I remembered the anxious passenger on the 11 a.m. flight and quickly checked on flight 1751; it had landed safely. I resisted a nearly overwhelming urge to leave my counter and find out which flight had crashed, and instead turned back to the line of passengers, trying to camouflage my emotions.

The same scene was being replayed in a hundred other cities as bits of information filtered in from the crash site. Continental Flight 1713, a McDonnell Douglas DC-9 bound for Boise with 77 passengers and a crew of five, lay in three pieces 250 feet off Stapleton's Runway 35 Left.

An off-duty employee caught the news on TV and immediately called the Omaha office. Early reports said that as many as 200 people had been killed. A DC-9 cannot hold that many passengers, so it was clear that initial media accounts would be inaccurate. When the chance came to break away from the ticket counters, we stood around the teletype machine waiting for details. It was then I realized the father and

Bill Firestone

son I checked through were booked on that flight.

It was 6:30, more than three hours after the crash, when Continental released the announcement of an accident in Denver involving 1713. There were some fatalities but no details were available. The Denver County coroner's office was responsible for releasing all information on fatalities and survivors, and not everyone on board had been positively identified yet. Survivors had been rushed to seven hospitals and had to be tracked down. In addition, several passengers had used other people's tickets and their names didn't appear on the manifest.

Over the next few days, as the details finally emerged, I felt depressed, guilty, angry, and resentful—emotions over which I had little or no control. I learned that the father and son I checked through had been on board, the son surviving, his father one of 28 fatalities. I had only talked to them briefly, yet somehow I felt responsible. They were my passengers and I had allowed them to take that flight. I fought back tears as I drove to and from work the rest of the week.

I found myself resenting Continental. It was an illogical reaction, an anger that erupts when tragedy strikes. I had to blame *someone,* and I couldn't bring myself to blame Frank Zvonek or Lee Bruecher, the captain and the first officer. They would have had little or no control over what had happened if there was any truth to the theory that wingtip vortices from a landing 767 caused the crash. I wanted to blame Texas Air president Frank Lorenzo, who merged People Express and Frontier Airlines with Continental and Eastern late in late 1986 and early 1987. Such rapid growth sometimes taxed our ability to deliver reliable service. But airline mergers don't cause crashes.

Somewhere in this emotional hodgepodge was the selfish feeling of wounded pride. So many of us had worked so hard since the mergers to improve the company's image. Now, in one horrific instant, those efforts, which were just beginning to pay off, lay in pieces along with 1713.

I also resented my customers in the days following the crash. I had little patience with their problems and none when someone would parrot the premature speculations of the media. It would be months before the National Transportation Safety Board issued its final report, and even then we might never know precisely what caused 1713 to go down.

But we were buffered by the 500 miles between us and the agonizing scenario played out at Denver. Due to miscommunications between the control tower and Continental operations, the first volunteers who rushed to the crash site believed that an airplane had simply slid off the runway into the mud. Instead, they found dazed survivors wandering amid the inverted wreckage. Thick snowfall, dwindling daylight, and an eerie silence shrouded the site, isolating it from the rest of the world. A supervisor told the volunteers that if they felt they couldn't face what they were about to find inside the remains of the aircraft, they were free to return to the terminal. No one left.

It was only after the last victims had been pulled from the wreckage that the magnitude of what had happened began to sink in. Rescuers felt the need to talk to someone about what they'd experienced. With management's approval and support, professional counselors were called in and began debriefing sessions the night of the crash. Almost immediately employees began showing up, mostly to talk.

For the next week employees talked to counselors not only about the crash but also about problems at home and at work that the accident seemed to exacerbate. "Little things at home that usually never bother me I found myself blowing completely out of proportion," confided one agent. The most common feelings were guilt and helplessness. Agents who fought to keep terminal operations running despite mounting delays and endless questions from passengers felt guilty for not having helped at the crash site. Employees with no training in crisis counseling who had been sent to hospitals to aid survivors and their families instead wound up being comforted by the survivors. Even those who rescued survivors and recovered bodies felt they hadn't done enough. One rescuer recalled holding the hand of a man trapped in the wreckage and feeling utterly helpless when the man died. "At least you were there with him," a counselor reminded the agent. "He didn't die alone. That had to mean a lot to him."

While the accident inexorably drew together those who had once been divided into Frontier and Continental camps, it demoralized others. Some would remove jackets with company insignias as soon as they left work, ashamed to let others know whom they worked for. Reservation agents were reluctant to answer questions about the crash but resented callers too concerned with vacation plans to mention it.

The business of flying, like the business of living, goes on. But the counselors tell us that we will never be our old selves again, that trauma and stress have forever changed us.

—Bill Moore

Wild Blue Yonder: Money, Politics, and the B-1 Bomber *by Nick Kotz. Pantheon Books, 1988. 314 pp., b&w photos, $18.95 (hardbound).*

Superfortress: The B-29 and American Air Power in World War II *by General Curtis E. LeMay and Bill Yenne. McGraw-Hill, 1988. 222 pp., b&w photos, $18.95 (hardbound).*

For more than 50 years the U.S. Air Force has been infatuated with the strategic bombing doctrine—the theory that one can win wars by bombing an enemy's vital industries from the air—and the heavy bombers required to put the concept into practice. These two books deal with that enduring obsession.

Retired Air Force General Curtis LeMay and writer Bill Yenne's *Superfortress* outlines the origins and operations of the B-29, the airplane that firebombed Tokyo in the spring of 1945 and dropped atomic bombs on Hiroshima and Nagasaki. *Superfortress* demonstrates—to the authors' satisfaction at least—that the bomber and the doctrine it fulfilled were products of genius. Nick Kotz's *Wild Blue Yonder* describes the logical outcome of the Air Force's long fixation on strategic bombers: the B-1, an airplane that costs at least $238 million apiece. Both books are flawed by errors, but Kotz's book makes a genuine contribution to political discussion and should be read by citizens concerned with the workings of their government.

Superfortress is based on LeMay's tape-recorded recollections of his experiences as World War II's premier bomber commander in Europe and the Pacific, with the emphasis on the latter theater. Yenne, abundantly ignorant about the war, supplies editing, a preface, an epilogue—and acceptance of LeMay's narrow views on the success of strategic bombing. One reads nothing of the crucial part long-range escort fighters played in the strategic campaign against Germany, and, except for one brief quote from an obscure source buried deep in the book, one is never told of the critical accomplishments of the Navy, Army, and Marines in defeating Japan.

The book, however, has some merit. When LeMay stops pontificating on the value of strategic bombing, ceases complaining about the blindness of all ground officers, and begins describing the ordeals of his Pacific Command and his efforts to forge a fighting team under daunting circumstances, his crusty, no-nonsense pragmatism is a treat. LeMay bulldozed everything that interfered with mission accomplishment. He reformed logistics and maintenance to keep his bombers flying, and he retrained aircrews to his standards. He placed exceptional value on his crews and even got Mao Tse Tung and the Communists to aid in aircrew rescue. (Mao's people wanted opium for their efforts and LeMay provided it, although this required some creative bookkeeping.)

One doesn't need a ruler to draw a straight line from the doctrine that produced LeMay's B-29 to the 100 B-1s that sit alert on Strategic Air Command bases around the country today, but one

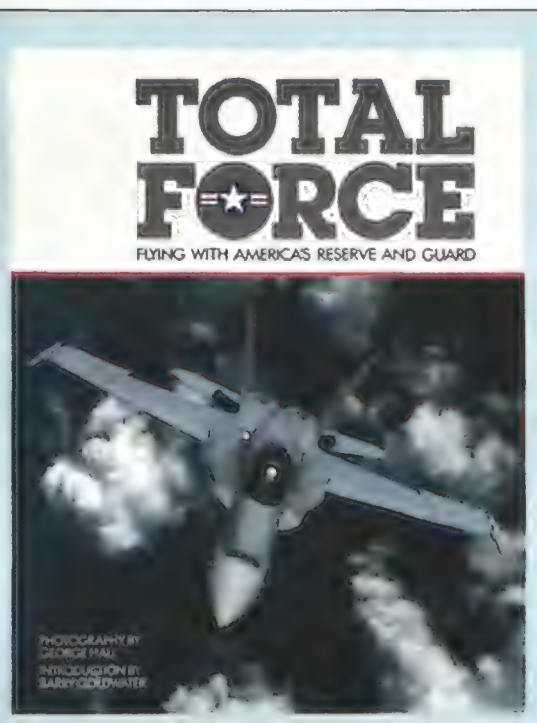
would need a bank full of money: for the price of those 100 B-1s, you could buy more than 4,000 B-29s. Pulitzer Prize winner Nick Kotz focuses on the expense of the new bomber, and on the decisions at all levels that produced the airplane.

Wild Blue Yonder is a case study of how the armed services work with Congress and the defense industry to produce weapons systems of dubious worth. Kotz's book is filled with minor errors stemming from his lack of understanding of the Air Force and the nature of deterrence, but his appreciation of Congress and those who lobby it helped him produce a necessary work. Kotz asks: "Are decisions to build new weapons based on real national-defense needs? Or are they governed by narrow political, economic, and military special interests?" He concludes that the latter is correct, and makes a compelling argument.

Kotz mutes his anger because he recognizes that "[w]inning or losing a single large contract may determine the fate not only of companies but of communities."

This leads business executives to fight desperately to win contracts, and forces members of Congress to battle for weapons systems that can be built by their constituents.

The author shows how presidents (not always innocent in this turbulent milieu), in attempting to kill unneeded systems, are often undermined by the defense department. The White House is also routinely subverted by members of Congress who put the necessities of their



Total Force: Flying with America's Reserve and Guard *photographs by George Hall. Thomasson-Grant, 1988. 168 pp., color photos, $39.95 (hardbound).*

For more images of "Old Gun" (pp. 54–60) craft, this is the place to look.

district or state above the president's perception of the national interest. To garner support from as many legislators as possible, Rockwell, the B-1 manufacturer, subcontracted the production of B-1 parts to companies in 48 states and as many congressional districts as possible, even having other companies make components that Rockwell could more easily have manufactured itself.

While Kotz understands the reasons for the mess defense contracting is in, he is unwilling to excuse it. To continue to allow everyone involved in defense procurement to work for his own parochial end is dangerous to the general welfare. Further, as the book demonstrates in example after example, the questionable means these individuals often employ to achieve their ends are morally corrupting. Kotz keeps his outrage on low boil throughout, but it comes through clearly nonetheless. *Wild Blue Yonder* is a call to action that should not be ignored.

—Alan L. Gropman is a military historian and author of several books and numerous articles and reviews.

Last Flight *by Amelia Earhart. Orion Books, 1988. 135 pp., b&w photos and illustrations, $9.95 (paperback).*

"Lae, New Guinea, June 30th [1937]. After a flight of seven hours and forty-three minutes from Port Darwin, Australia, against headwinds as usual, my Electra now rests on the shores of the Pacific . . . . Somewhere beyond the horizon lies California. Twenty-two thousand miles have been covered so far. There are 7,000 more to go." Thus wrote Amelia Earhart, on the brink of success.

The Fourth of July, 1937, was to be the day Earhart returned to the United States from a record-breaking around-the-world flight. Five years earlier she had become the first woman to fly solo across the Atlantic. And in the interim she set record after record. But the headlines that morning recorded another story altogether: the most celebrated American aviatrix in history was missing somewhere between Lae and Howland Island. The disappearance of Earhart, navigator Fred Noonan, and her twin-engine Lockheed Electra on the last leg of their journey has been a source of speculation ever since: Was she on a fact-finding mission for the U.S. government on the eve of World War II? Did she crash-land in the Marianas far wide of her purported course? Did she and Noonan simply fall prey to fate and crash somewhere in the Pacific?

We may never be certain. But one thing is sure: Amelia Earhart was far more than a talented flier. She was a buoyant, thorough reader of the human condition, a woman whose keen skills of observation were coupled with a gently ironic wit. In addition to knowing how to recover from a spin and how to hold opposite rudder in a crosswind landing, she knew how to put words on paper and make them sing.

"Cows seem to have a special place about the fringes of my flying," she wrote in Brazil near the beginning of her global flight. "A group of them were munching breakfast in the heavy grass at the edge of Fortaleza's airport when we appeared at dawn. They just didn't like the commotion created by the Electra's engines warming up. They showed their hurt feelings not by silly protest, but by gravely stalking away, turning a completely cold shoulder (plus hind-quarters) on the interloper. Proud cows, those."

Earhart was also something of a philosopher. *Last Flight,* which was "arranged" by her husband George Palmer Putnam from dispatches, charts, and visas she mailed him en route, begins with a simple assertion: "Pilots are always dreaming dreams." And as her roughly chronological narrative reveals, this truth was as much a part of her as her constantly oil-stained flight gear. Breaking out on top

of overcast at 8,000 feet, she muses, "But how many of the earthbound realize the relative nearness of sunlight above the cloud-covering? How many know that perhaps only 3,000 feet above the grey dank world my plane, if I will it, may emerge into sunlight over a billowy sea of clouds stretching away into blue infinity[?]" The operative phrase—indeed, the underlying theme of *Last Flight*—is "if I will it."

Readers coming to this work for the first time—it has been out of print since 1937—may be surprised to find that her credo has a contemporary relevance: the idea that women have as much talent for traditionally male roles as men. As she somewhat laconically summed it up: "Then, too, there was my belief that now and then women should do for themselves what men have already done—and occasionally what men have not done—thereby establishing themselves as persons, and perhaps encouraging other women towards greater independence of thought and action. Some such consideration was a contributing

reason for my wanting to do what I so much wanted to do."

I suspect that if Earhart had lived another 50 years, her mourning for the seven pioneers who died on the *Challenger* would have been tempered by some measure of pride in the fact that two among them were women. For if there is one thing Earhart and the *Challenger* Seven had in common, it was a sense of adventure, of probing the unknown. Or as Amelia Earhart put it so much more evocatively in a poem called "Courage,"

Courage is the price that life exacts for
granting peace.
The soul that knows it not, knows no
release
From little things . . .

—Douglas Greenwood is a Washington, D.C.-based writer and pilot. His father became a Marine aviator in World War II largely because of a speech he heard in high school. The speaker was Amelia Earhart.

***Chuck Yeager's Advanced Flight Trainer** by Electronic Arts. Available for Apple II series, $39.95; Commodore 64/128, $34.95; IBM, Tandy, and compatibles, $39.95. IBM version requires 256K RAM; DOS 2.0 or higher; CGA, EGA, or Hercules MGA. Reviewed in IBM version.*

How would you like to fly with Brigadier General Chuck Yeager sitting by your side? Advanced Flight Trainer lets you do just that in 15 different airplanes, from World War I craft to a few that are still on the drawing board. You can learn basic flying skills in a Cessna 172 or aerobatics in a P-51 Mustang. You can race with other F-18s in a closed course or fly a P-51 at the Reno Air Races. And you can test-fly all of them and develop your own set of specifications for each. All with Yeager looking over your shoulder, ready to admonish you whenever you goof.

I got my first message from my lofty copilot while I was trying to taxi a Samurai out of the hangar. His face appeared on the screen, and below were the words "What a wreck. Have you tried fishin'?" No, but I did go back for some flight instruction in the Cessna 172. Next thing I knew, a message flashed on the screen telling me I'd exceeded maximum speed, the screen went red, and then there was the general looking at me again. "That's a sorry way to land an airplane," he said.

It didn't take long to learn that I wasn't going to get any praise no matter how flawlessly I executed a landing, a Cuban 8, or a split S. When Yeager finally showed up and said, "You're no friend of mine!" I fixed him by turning the whole thing off.

In addition to Yeager's snide comments, AFT has a few other annoying quirks. Whenever you call up the program it shows the profile of one of the airplanes you can fly and asks for a technical specification such as the service ceiling. That information is in the instruction manual, but it's bothersome to have to look it up every time you want to take a spin. The menus are awkward. And it's possible to land your craft in a lake and get a message telling you to "Taxi to Parking." The flight lessons can

be frustrating because they end when a certain amount of time has gone by—just enough to try a maneuver or two—not when you've mastered the material.

One of the nicest features of AFT is the variety of aircraft you can fly. And the program lets you view your airplane from the perspective of the tower, a chase plane, or a satellite. There is a certain charm in watching a Sopwith Camel meander through the sky in front of you while you watch and control it from a chase plane.

You can play AFT with the FlightStick ($79.95 from CH Products), which has a "contour pistol grip" that "feels and acts like the real thing," or with a Maxx yoke ($99.95 from Alturas Corporation). Each enhances the flying experience and is certainly preferable to the complicated keyboard commands you would otherwise have to use.

What you get out of AFT depends only on your expectations. If you want to try your hand at a variety of airplanes and supersonic jets or formation flying and air racing you can get hours of enjoyment out of it. If you're the aggressive type up in the sky looking for something to shoot down you'll soon be disappointed. And if you're lousy behind the stick, you'll soon have your fill of Brigadier General Chuck Yeager. It's not a bad game. But all in all, I'd just as soon have the option of leaving the general on the ground.

—Elaine de Man is a freelance writer who lives in Alameda, California.

Credits

Why I Don't Fly. Still earthbound, Daniel Pinkwater is a weekly commentator on National Public Radio's "All Things Considered."

Send Down the Clowns. Private pilot O.H. Billmann is an airframe and power plant mechanic who advises both U.S. and foreign armed services.

Reef Encounter. Terry Gwynn-Jones is a writer living in Brisbane, Australia.

Piaggio. For better or worse, Stephan Wilkinson owns an Italian airplane—a Falco F.8L.

Space Shots. Alcestis R. Oberg is the author of *Spacefarers of the 80s and 90s: The Next Thousand People in Space* (Columbia University Press, 1985).

Old Gun. Carl Posey's novel *Red Danube* was recently published in paperback by Worldwide Library. A private pilot and an editor at Time-Life Books, Posey sustained 8 Gs while researching this story ("I'm shorter now," he says).

George Hall toured the United States and Europe as the Goodyear Blimp photographer in the 1970s. He has published 10 books on military aviation, including *Top Gun* (Presidio Press, 1987).

Looking Down on History. Freelance writer Richard Wolkomir has written for *Omni, McCall's,* and *Playboy.* In 1984 he received the American Association for the Advancement of Science-Westinghouse Award for distinguished science writing in magazines.

Harvesting the Wind. A long-time pilot and aviation writer, Berl Brechner has always been fascinated by things that move through or are moved by the wind.

Blast From the Past. David DeVorkin is a curator in the National Air and Space Museum's Space Science and Exploration Department.

My Friend, G.M. Aviator Elinor Smith made her first solo flight in 1927 at the age of 15. During her flying career, she set records for speed, endurance, refueling, and altitude. In the 1930s Smith worked as a magazine editor and a commentator for NBC radio.

"There Has Been a Crash in Denver." Bill Moore's work has been published in *Discover* and *Popular Science.*

"The Satellite Sky" Update/8

These regular updates to **"The Satellite Sky"** chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

Deletions

90 to 300 MILES

Cosmos 1932 down, date unknown

Cosmos 1935 down 4-8-88

Cosmos 1936 down 5-18-88

Cosmos 1938 down 4-25-88

Progress 35 down 5-5-88

Launched but not in orbit

90 to 300 MILES

Cosmos 1941 USSR photo recon	4-27-88	down 5-11-88
Cosmos 1945 USSR photo recon	5-19-88	down 5-31-88
Foton USSR research	4-14-88	down 4-28-88
Progress 36 USSR research	5-13-88	down 6-5-88

Inoperative but still in orbit

300 to 630 MILES

Cosmos 1758
Cosmos 1898

630 to 1,250 MILES

Cosmos 1716-23

21,750 to 22,370 MILES

TV-Sat 1

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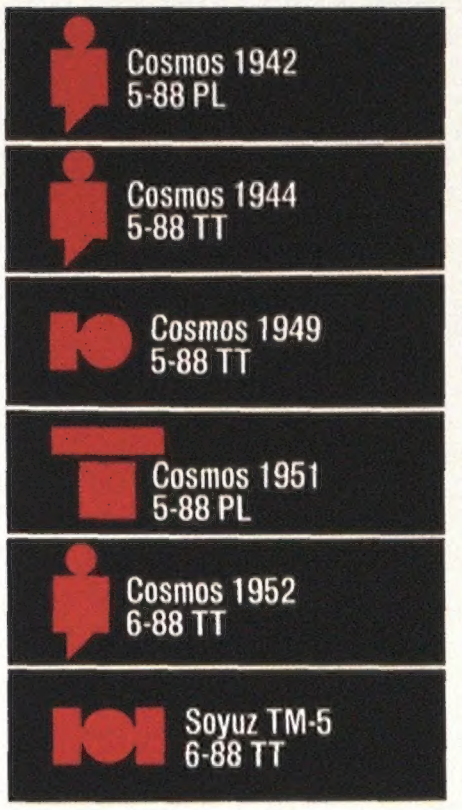
New launches

90 to 300 MILES



300 to 630 MILES

630 to 1,250 MILES

6,200 to 13,700 MILES

21,750 to 22,370 MILES

In the Wings . . .

Paul Conklin

Sagdeev Speaks, Daniloff Listens—Roald Z. Sagdeev is the high-profile director of the Soviet Union's Space Research Institute. He dresses nattily, speaks English eloquently, and has charmed Western audiences with his proposals for joint Soviet-U.S. exploration of Mars. But some émigré scientists accuse him of playing hardball at home and following a secret agenda abroad. Nicholas Daniloff probes the politics and personality, past and present, of the chief spokesman for *glasnost* in space.

George R. Lawrence, Shutterbug—"The Hitherto Impossible in Photography is Our Specialty," he proclaimed. A pair of balloon accidents convinced America's first aerial photographer that kites would make better platforms for the huge cameras he used to capture such images as the 1906 "San Francisco in Ruins."

Aurora Patrol—It's cold enough to freeze a six-pack in minutes. But a small band of scientists braves the hostile nights of Greenland to chase the elusive northern lights.

The International Airplane—A poster portrays what parts come from where.

L-5—Officially it no longer exists: the L-5 Society has been subsumed by the National Space Society. Have the adjustments in the hierarchy dampened the membership's evangelistic pro-space fervor?

The East Coast's *Other* Spaceport—More than 13,000 rockets have been launched from this sandy strip along the Atlantic. Few space buffs would be able to find the place; Wallop's Island is 600 miles north of the Kennedy Space Center.

NASA

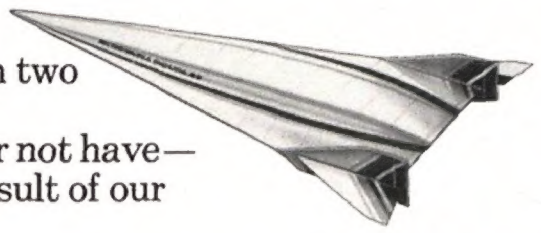
THE X-30 IS KID STUFF.

To soar with ease on swift, strong wings—farther, higher and faster than ever before. For a kid, that's the stuff dreams are made of.

Kid stuff, because it's your kids, and ours, who will benefit most from the advances in computational fluid dynamics required to build the X-30 National AeroSpace Plane (NASP).

With supercomputers, we're simulating the effects of air pressure, speed and heat on proposed X-30 airframes. This wind-tunnel-in-a-computer technology allows us to test-fly numerous airfoil shapes and configurations—rapidly, and without building models.

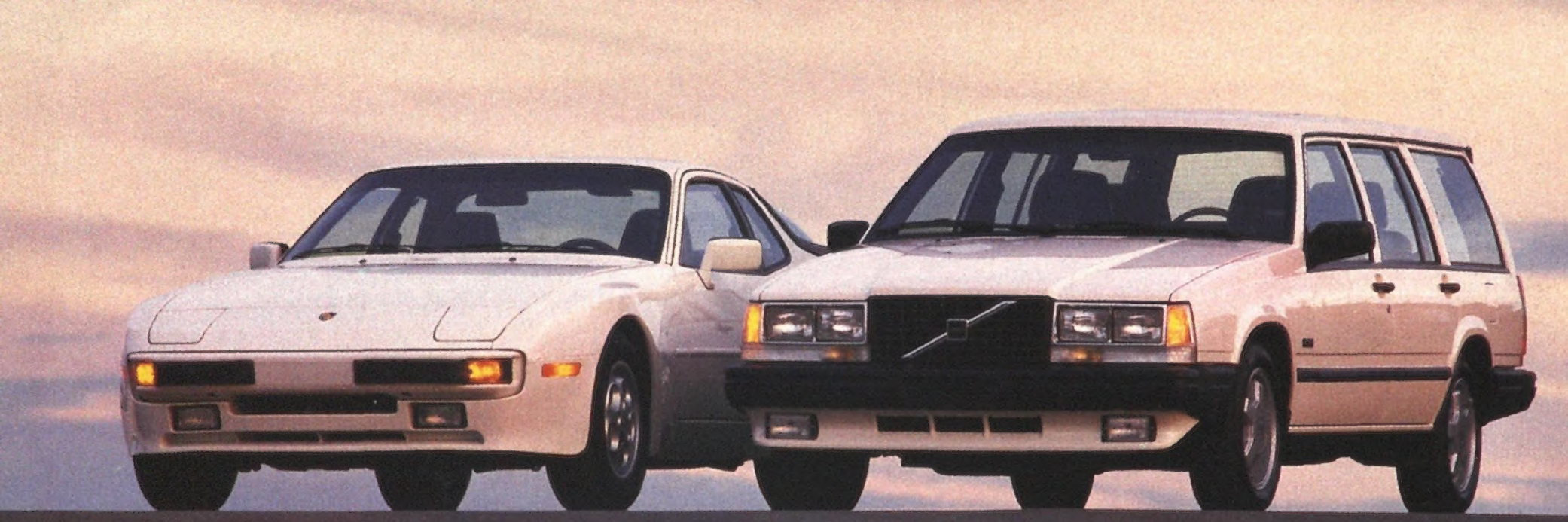
The X-30 is kid stuff, because it is our children who will move from Earth to space and back at far less cost than we do today. And one day fly from Los Angeles to Tokyo in two hours aboard an Orient Express.



And it is they who will have—or not have—world leadership in aerospace as a result of our nation's resolve now.

Let's not let them down.

MCDONNELL DOUGLAS



TO A RADAR GUN THEY LOOK EXACTLY ALIKE.

Forget the fact that the car on the left is a legendary performance car. And that the one on the right is a wagon.

A radar gun doesn't notice minor details like that. It focuses on only one thing: speed.

And from that point of view, the Porsche 944 and the Volvo 740 Turbo Wagon look remarkably similar.

In fact, in repeated quarter-mile tests, they came up with virtually identical numbers—both in elapsed time and miles-per-hour. In 0-60 tests, the Volvo wagon actually came out ahead of the Porsche.* Which is no small feat for *any* car. much less a wagon.

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